A TREATISE ON

HYGIENE AND PUBLIC HEALTH

B. N. Ghosh and J. L. Das

Basement
ST

1a 18

Gbh
a803

Old edition

HYGIENE AND PUBLIC HEALTH

DISEASES BUREAU
LIBRARY.

LSHTM
0011381769

TROPICAL DISEASES BUREAU
RECEIVED
28 APR. 191

A TREATISE

ON

HYGIENE AND PUBLIC HEALTH

WITH SPECIAL REFERENCE TO THE TROPICS

BY

BIRENDRA NATH GHOSH, L.M.S. (CAL. UNIV.)
FELLOW OF THE ROYAL INSTITUTE OF PUBLIC HEALTH, LONDON ; MEMBER OF THE GERMAN SOCIETY OF TROPICAL MEDICINE.

AND

JAHAR LAL DAS, L.M.S. (CAL. UNIV.)
HEALTH OFFICER, MANIKTALA MUNICIPALITY, CALCUTTA ; FORMERLY SPECIAL HEALTH OFFICER, GHAZIPUR, U.P.

WITH AN INTRODUCTION BY

COLONEL KENNETH MACLEOD, M.D., LL.D., F.R.C.S.,
INDIAN MEDICAL SERVICE (RETD.)
HONORARY PHYSICIAN TO HIS MAJESTY THE KING.

TROPICAL DISEASES BUREAU
LIBRARY.

Compliments.
HILTON & Co's.
Specimen. —

HILTON & CO.,
CALCUTTA.
1912.

All rights reserved.

Price Rs. 3-8 or 5s. net.

PUBLISHERS :—
HILTON & CO.,
109, COLLEGE STREET, CALCUTTA.

10628

PRINTED BY U. N. BHATTACHARYYA
HARE PRESS:
46, BECHU CHATTERJEE STREET, CALCUTTA

THIS VOLUME IS RESPECTFULLY DEDICATED

TO

The Officers of the Indian Medical Service

IN RECOGNITION OF THEIR VALUABLE WORK

IN THE CAUSE OF SANITATION

AND AS A TOKEN OF HIGH ESTEEM

BY

THE AUTHORS

Digitized by the Internet Archive
in 2015

https://archive.org/details/b21359969

Specimen.—
With HILTON & Co's.
Compliments.

129

10.6.13

PREFACE.

So much attention is being paid by the Government to the sanitation of India that no apology is needed for the appearance of this book. A book which is neither too large nor too small, written in the form of a text-book and having special reference to the tropical climates has been a distinct want. But, it must be said at the outset that we do not presume to replace any of the standard works on the subject—far from us be any such intention. On the contrary we have drawn largely from most of those works, and have received valuable assistance from Notter and Firth's Theory and Practice of Hygiene, Parkes and Kenwood's Hygiene and Public Health, Newsholme's Hygiene, and McNally and Cornwall's Sanitary Handbook for India. Particular attention has been paid to the description of food, disposal of refuse and septic tanks. In the preparation of these portions we are specially indebted to the works of Hutchison, McCay, Burney Yeo, Sutherland and Clemesha. A few pages have also been devoted to the description of insects as carriers of diseases, and the chapter on infectious diseases has been written with special care, giving the latest information with regard to their preventive measures. Besides the authors already alluded to, we are grateful to many others, specially to Sir Patrick Manson, Lefroy, Hehir, Sir Ronald Ross, and to Sir Pardy Lukis and Major

Blackham whose latest work on Tropical Hygiene has been of the greatest use to us.

It has been our endeavour to make the treatise concise, thoroughly reliable and up-to-date.

We gratefully acknowledge our indebtedness to the various works detailed in the list of reference, and we hope that this will be accepted in lieu of any omissions in the text.

We desire to take this opportunity of acknowledging gratefully the sympathy shewn to us by Col. Kenneth McLeod, I. M. S. (retd.) who has condescended to take the trouble of writing the introduction for the book; and our best thanks are also due to Major J. W. D. Megaw, I. M. S., for kindly going through certain portions of the manuscript notes and for his valuable advice and encouragement.

In conclusion we have to thank Messrs. Lawrence and Mayo and various other firms (mentioned in the text) for kindly supplying us with the woodcuts.

B. N. GHOSH,
J. L. DAS.

College Street,
October, 1912.

CONTENTS.

PAGE.

INTRODUCTION xv

Chapter

I. **Water:**
Sources—storage and delivery—properties and impurities—purification—examination . 1-34

II. **Air:**
Composition—impurities—diseases due to impurities—examination 35-47

III. **Ventilation and Cooling:**
Amount of air required—system of ventilation—purification of air—examination of ventilation—heating and cooling . . . 48-64

IV. **Offensive Trades** 65-70

V. **Soil:**
Soil features influencing climate and health—varieties of soil—diseases arising from soil 71-83

VI. **Houses and Buildings:**
Construction of houses—residential quarters—lodging houses—bustees and huts—bake houses—cowsheds 84-93

LIST OF ILLUSTRATIONS.

FIG. PAGE.
1. Diagramatic representation of Strata 7
2. Pasteur-Chamberland Filter 25
3. Berkfeld Tap Filter 26
4. Berkfeld Filter 26
5. Four-ghurra Filter 27
6. Various provisions for Ventilation 54
7. Private Latrine 184
8. Seat arrangement of Private Latrine 185
9. The Commode 187
10. Valve Closet 194
11*A*. Long-hopper Closet 195
11*B*. Wash-out Closet 195
12. Wash-down Closet 196
13. Syphon Flushing Cistern 197
14. Trough Water-closet 197
15. S Trap 200
16. P Trap 200
17. Application of smoke test 202
18. Calcutta Crematorium 220
19. Six's Thermometer 252
20. Solar Radiation Thermometer 253
21. Fortin's Standard Barometer 254
22. Anemometer 257
23. Wet and Dry bulb Thermometer 259
24. Sunshine Recorder 261
25. Rain Gauge 264
26. Culex and Anophelene Larvæ 274
27. Heads of Anophelene 275
28. Rat flea and Bed-bug 282

INTRODUCTION.

In no department of human knowledge has Auguste Compte's famous generalisation been so conspicuously manifest as in the science of health. The three phases—theological, metaphysical or theoretical, and positive or inductive have succeeded each other as mankind has progressed from infancy to maturity, from savagery to civilisation.

In the earliest endeavours to explain and combat disease, disturbance of health was attributed to supernatural agencies, to deities and demons, to obscure occult influences exercised by the stars, fairies, witches and the like ; and restoration of health was sought by means of prayers and sacrifices, conjuration and exorcism, charms and spells. Thus, in India, the scourges of smallpox and cholera were held to be under the control of goddesses to whom temples were erected, and votive offerings presented—with prayers and prostrations.

In the course of intellectual awakening the symptoms of disease were noted and recorded, different forms of disease recognised and named, and empirical remedies discovered. Medicines took the place of *muntras*, associated in their selection and administration with superstitious observances. Notions regarding the nature and causation of diseases were crude and speculative, and fanciful theories were formulated to explain observed phenomena. To this category belonged the *bayu*, *pitta*, and *kopha* of ancient Hindu Medicine. Diseases were attributed to malignant intra-somatic entities or to special deleterious alterations of solids, humours, or vital processes; and the extension of the hypothetical *materies morbi* was sought to be accomplished by bleeding, counter-irritation, purgatives, emetics and strong drugs of a spoliative character. Still later after the medical renaissance of the fourteenth and fifteenth centuries, when anatomy, normal and morbid, physiology and pathology were systematically investigated, theories of all kinds were invented—mechanical, dynamic, chemical, vital, spiritual, etc., and various formulæ or "pathies" devised to account for morbid disturbances and guide remedial measures.

Another and more recent set of theories were founded on observed influence of the environment on the prevalence and spread of epidemics, and pathogenetic factors, cosmic, telluric, climatic, meteoric and so forth were postulated, while vague doctrines of susceptibility, idiosyncrasy and resistance were stated to account for the limited and exceptional operation of universal or general forces.

Finally, statistical data were collected and tabulated, and endeavours were made to extract from these pathological and etiological laws. All these methods yielded unreal inferential views, and practical, useful knowledge regarding causation and prevention awaited direct research by means of improved instruments and processes—mainly microscopic and chemical—observation being materially aided by animal experimentation.

Positive and inductive methods have been deligently pursued during the last half century with splendid results eminently powerful for good. Efforts to solve pathological and etiological problems have been directed to the close study of diseases in the subject thereof and of the immediate environment. The zymes or ferments which were supposed to be the disturbers and destroyers of healthy vitality have been found to be micro-organisms invading the body and producing deleterious toxins, and the means of combating their noxious action resorted to by modern hygiene consist in (1) preventing the access of these parasites into the living organism; (2) strengthening the natural processes of resistance, or artificially establishing immunity by inoculation and otherwise; (3) destroying the microbes *in corpore,* neutralising the poison elaborated by them or procuring their elimination; and (4) tiding the organisms over the period of their active life and baneful operation. Study of the life history of these pathogenetic microbes has revealed the rôle which various animals play in harbouring, developing, multiplying and transmitting them, and the science of hygiene has to take account of their life and activity in the animal as well as in the human host. This study confers a new power on the practice of special sanitation. Moreover, epizootics are caused similarly to epidemics and the subject of comparative pathology has become a necessary companion and supplement to human pathology, men and animals undergoing a community and reciprocity of suffering.

The science of hygiene has been defined as the gospel of cleanliness and the importance of pure air, water and food, and of clean habitations and surroundings cannot be overestimated. These things make essentially for health and for the reduction, prevention and cure of disease. Moses and Manu were among the greatest law-givers that the world has seen; and their elaborate regulations were largely concerned with personal and communal cleanliness. Although among both Hebrews and Hindus the rules of cleanliness have been observed with scrupulous care as religious rites, they have not protected these peoples from deadly maladies. Still, general sanitation has been productive of good effects. In England attention to personal, domestic and communal cleanliness has banished plague, cholera, leprosy, ague, typhus and relapsing fevers, reduced the incidence and mortality of enteric fever and tuberculosis, and lowered the general death-rate ; and, to cite an Indian illustration, in Calcutta general sanitation—improved conservancy and drainage, the supply of pure water and abolition of foul tanks and wells—has obliterated malaria, reduced the prevalence and fatality of dysentery, lowered the incidence and death-rate of cholera, produced a general improvement in the health of the population and raised the standard of well-being. Still, the practice of general sanitation, however commendable and beneficial, has been as regards the prevention of infective diseases a groping in the dark, and has been necessarily less effective than special sanitation founded on exact knowledge of the causes of particular maladies, and on a study of the measures required to combat the noxæ to which they are severally due.

The vague attempts of former days to abolish a supposititious malaria were comparatively ineffective, and, in contrast, the discoveries of Laveran, Manson and Ross have placed at our disposal, means of extirpating malarious fevers which have been conspicuously successful in Ismalia, Panama, Havana and other places; just as exact knowledge of the causation of yellow fever has banished that plague from Cuba and of Mediterranean fever from Malta, general sanitation in old days made no impression on smallpox until Jenner's immortal discovery gave us in preventive vaccination, if exhaustively applied, a means of extirpating disease. So in surgery, general cleanliness of wards and wounds did not suffice to extinguish hospitalism, until the genius and industry of Lister devised a system of special prevention which has rid our hospitals of erysipelas, septicæmia and gangrene and saved thousands of lives.

The merit of a treatise on hygiene depends on the clearness and accuracy with which it sets forth in plain and simple language the facts and doctrines bearing on causation and prevention which have been accumulated in recent years and the most easy and effective manner of their practical application. From this point of view the manual compiled by Drs. Birendra Nath Ghosh and Jahar Lal Das, which I have carefully read, commends itself to approval and gives promise of usefulness.

Dr. Birendra Nath Ghosh has evidently inherited the power of clear exposition and orderly arrangement of his subject, which was possessed in so high a degree by his gifted father the late Dr. Rakhal Das Ghosh, of whom I retain a most pleasing remembrance as a devoted and intelligent assistant and an excellent practitioner.

The book is well fitted for use as a text-book in colleges and schools and both medical men and laymen may derive instruction and profit from its perusal.

Much remains to be done in India to apply the deductions of rational hygiene to the special and difficult circumstances of the Indian Empire. The education of the laity in sanitary principles and practice is indispensable to the harmonious and effective performance of sanitary work.

K. MACLEOD.

DUNCAPLE, WESTEND,
Hants, September, 1912.

Specimen.—
With HILTON & Co's.
Compliments.

HYGIENE
AND
PUBLIC HEALTH.

CHAPTER I.

WATER.

Water, though not strictly speaking a food, is absolutely necessary for the maintenance of life, both animal and vegetable. It is mainly used as a solvent and diluent in the human economy, but for these purposes only a small quantity would suffice. With the progress of civilisation, however, the demand for water has considerably increased and it is now required for :—

1. Domestic use for the following purposes :

   (*a*) As food for building tissues of the body, maintaining fluidity of blood and helping in the excretion of waste matters.

   (*b*) Cooking and washing purposes.

   (*c*) Personal cleanliness.

2. Municipal and trade purposes.

3. Hospitals.

4. Washing stables and carriages, and for horses.

A liberal and pure supply of water is of primary sanitary importance. An insufficient or impure supply would necessarily lead to deterioration of health.

Quantity of water required.—The amount of water required daily for domestic use varies greatly, and depends mainly on the habits of the people and the particular sanitary arrangements of the place. The quantity of water required has been variously estimated by different observers. Parkes and Kenwood give the following as the daily allowance for all purposes :

		Gallons per head daily.
Household	Fluids as drink ...	... 0.33
	Cooking ...	... 0.75
	Ablution ...	... 5.00
	Utensil and house washing	... 3.00
	Laundry washings ...	... 3.00
	Water closets ...	... 5.00
Trade and manufacturing	...	... 5.00
Municipal	Watering streets, baths, fountains, flushing sewers and extinguishing fires.	... 5.00
		Total 27 .08

In hospitals 40 to 50 gallons per head must be supplied daily.

In India the daily allowance per head should be as much as 30 gallons but in summer much above this figure becomes necessary.

SOURCES OF WATER.

All water is primarily derived from *ocean*, and in tropical regions the evaporation of water into the air is very great, and it has been estimated that about 700 gallons are evaporated every minute from each square mile of ocean surface. Winds blowing over a large expanse of water become laden with moisture, and as soon as the cooling effect is produced by a lower temperature, it returns to the earth as *rain*, *snow*, *dew*, *mist* or *hail*. It follows, therefore, that the *condensed water* from the air is the principal source of all our water supply. But the following are the common direct sources :—

1. **Rain Water :**—Rain as it falls is the purest water which occurs in nature. In passing through the air it takes up certain gases chiefly nitrogen, oxygen, a little carbonic acid, traces of saline matter, common salt, sulphates, particles of suspended matter, soot, dust, microbes, &c. When collecting from the surface of the ground the area should be rendered impervious by asphalting or cementing. The number of bacteria found in rain water in winter is less than in summer, and the water sometimes becomes coloured from the presence of *protococcus pluvialis* and spores of fungi.

Rain water in manufacturing towns is unfit for human consumption as it becomes mixed with sulphurous and sulphuric acid, soot, &c. When collected from roofs of houses the first portion is very filthy as it washes down droppings of birds, soots, &c., and should, therefore, be thrown away. By fixing "Robert's Rainwater Separator" on the rain water pipe the latter portion of rain water can be collected as it allows the first portion to run to waste.

Rain water is naturally free from pathogenic organisms especially cholera and enteric germs. It is very soft owing to the absence of salts of lime and magnesia, and is, therefore, suitable for washing and bathing purposes. It is very palatable being much ærated, but has a corrosive action on lead. In India no proper arrangement can be made for collecting rain water as its fall is limited to certain seasons only.

The amount of rain which falls is measured by a *rain gauge*, and is expressed in inches of depth. A rainfall of 1″ in depth corresponds to about $4\frac{3}{4}$ gallons on a square yard or 22, 617 gal. (101 tons) on each acre.

The following formula is generally used :—

$$\frac{\text{Area in sq. feet} \times 144 \times R}{1728} = \text{water in cubic feet.}$$

$$R = \text{rainfall in inches.}$$

In one cubic foot of water there is about $6\frac{1}{4}$ gallons (6·23 gal.) of water.

In estimating the annual yield of water from rainfall and the yield at any particular time, we must know the maximum annual rainfall, the minimum, the average and the period of the year when it falls, and the length of the rainless season.

II. **Snow Water and Ice** :—These are fairly pure, but if ice be derived from polluted water it is not free from danger.

III. **Upland Surface Water** :—This is water collected and stored in hilly districts at the head of rivulets or streamlets. The water may be collected in some natural lakes as in Loch Katerine, for the supply of Glasgow, or in some artificially constructed lakes made by building an earth or masonry dam across the outlet of the valley, as in the city of Bombay or Liverpool. Such a water nearly approaches rain water. There is an absence of ammonia, nitrites and nitrates, and it is almost always soft and contains little dissolved saline. If the hills are covered with peat the water may be brownish from dissolved peaty matter. Unless in excess this water is practically harmless but if impregnated with too much peat it is said to give rise to diarrhœa. It can however be removed by running the water through a bed of sand. It has been shown recently that there are acid producing bacteria in the peat giving the water an acid reaction, and cases of "plumbism" have occurred from the use of such water distributed through lead pipes.

IV. **Springs** derive their water supply from the rain water which falling upon a pervious surface as sand, gravel, and chalk and percolating through the soil is accumulated there. This water is then known as *subsoil or ground water*. Beneath the pervious rock there is always at a greater or lesser depth a stratum of impervious character which holds up the water. The surface of this stratum is however sloping, and the water runs along this until the impervious stratum reaches the surface of the soil where it issues as a spring. The underground water is constantly changing its level and is moving slowly towards its outlet. Observations made on shallow wells show that this water has a curved surface from its highest level to its outlet. This curve rises abruptly from the outlet, but as it recedes it gradually becomes more or less horizontal.

Materials ordinarily present in common springs are atmospheric air and its gases, carbonate and sulphate of lime, common salt, chlorides of calcium and magnesium and sometimes organic matter.

Springs are of the following kinds :—

(*a*) *Land Springs* originate from percolation of water through beds of sand or gravel overlying an impervious stratum, and in fact are outlets of limited collections of subsoil water. They are often intermittent, ceasing to flow in summer (April to September) and starting again in autumn after percolation has commenced (October).

(*b*) *Main Springs* are deep-seated springs issuing from regular geological formations, e. g., chalk, oolite, greensand, &c. They usually give a continuous supply with certain variations during the different periods of the year.

(*c*) *Intermittent Springs* are usually found in valleys bounded by rivers and high hills. The flow depends on the amount of rain and subsoil water.

(*d*) *Hot or Thermal Springs.*—Where volcanic eruptions have ceased evidence of high internal temperature is often to be found in springs which continue to maintain their heat even for centuries. Thermal springs are not confined to volcanic districts alone, they may arise even in places hundreds of miles away from any active volcanic vent. As instances of this kind may be mentioned the *Sitakoond Spring* in India, and hot springs of Bath and Buxton in England.

Springs afford good sources of water supply for small communities such as villages. The greater the degree of percolation the water undergoes, the more perfect is the filtration and more clear and bright it becomes. It is generally *cool* and *palatable.*

Spring water is usually hard and therefore less suited for washing and cooking, but valuable for medicinal purposes on account of the mineral matters which it usually contains.

The temperature of springs affords a convenient but not always quite a reliable guide of the relative depth from which they have arisen. Some are just above the temperature of ice, others issue at the temperature of boiling water and between these two extremes every degree may be registered since the temperature of the earth rises approximately about 1°F. for a depth of every 50 or 60 feet.

To prevent contamination the area of the soil around the outfall should be fenced or enclosed by wall, and the water carried to the surface by pipes. The water may also be stored in reservoirs before distribution.

Yield of a Spring.—This is estimated by taking a vessel of known capacity and observing how long it takes the spring to fill it up. The output of the spring in one hour can thus be determined, and as the allowance per head is known the total quantity required is calculated.

V. **Wells :**—A well is an artificial pit or hole dug below the water level into which the subsoil water percolates. There are three kinds of wells :—

(*a*) Shallow or Surface wells.

(*b*) Deep wells.

(*c*) Artesian wells.

(*a*) *Shallow Wells.*—Wells with a depth of about 15 to 20 feet sunk into a superficial porous bed of sand or gravel which overlies an impervious layer of clay or rock are known as *Shallow Wells.* These wells draw mainly from the subsoil or ground water which percolates into them from the surrounding superficial soil, and therefore such water should be looked upon with suspicion, as it generally gets contaminated by impurities from the surface of the soil. When contaminated with animal pollutions such a supply becomes even more dangerous. If there be a privy or a cesspool in the vicinity, the offensive matters will only drain into this well and make the water more foul. In addition to these the surface well may also be a source of danger from more distant contamination. The supply of these wells is the underground stream moving steadily in the direction of its natural outlet, and heavy rains by raising the level of ground water may wash impurities from leaking cesspools, &c., into wells lying between and below the source of contamination and the outlet.

The danger of pollution in the case of surface wells may be reduced if the walls are made of impervious material, as solid brickwork set in cement, or glazed earthenware tubes, or iron cylinders. The top of the well should be

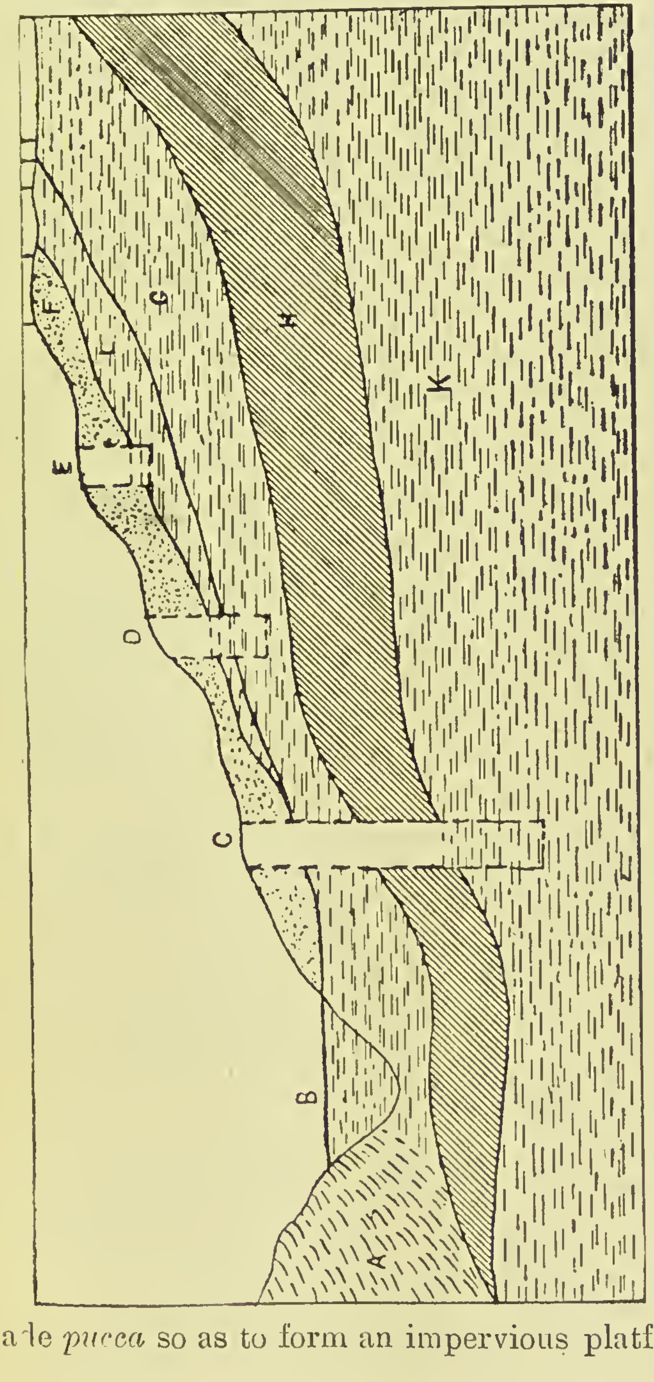

Fig. 1.

Diagramatic representation of Strata. A, Spring; B, surface water; C, Deep Well; D, Shallow Well; E, Cesspool; F, Porous soil; G, Subsoil water; H, impermeable strata; K, subterranean water in deep strata; L, the rise in the level of subsoil water and pollution of shallow well from Cesspool E.

made *pucca* so as to form an impervious platform and brought up to about two feet above the level of the ground in the form of a parapet wall to prevent surface washings getting into it. The well should better be protected by a cover. Wells should always be at a distance from any habitation and at least 50 feet away from any source of pollution.

(*b*) *Deep Wells.*—Deep wells are those which are about fifty feet or more in depth. These pass through a superficial porous bed and an underlying impervious stratum to reach the water-bearing strata. The walls of these wells are also to be made of some impermeable material at least to a depth of 25 feet or down to the level of the impervious stratum.

Deep wells are generally good sources of supply on account of the efficient filtration the water undergoes. But nevertheless they are exposed to contamination from sources similar to those of surface wells, especially when they are sunk in a pervious stratum like chalk or sand stones.

(*c*) *Artesian Wells.*—It often happens that the subterranean water finds its way downwards until it passes into some more impervious rock where it accumulates. If a hole be made through the upper impervious bed down to the watercharged stratum below, the water will avail itself of this artificial channel and will rise or even gush out above the ground. These wells are called *Artesian Wells* after the old province of Artois where they have been in use for a long time.

Norton's Abyssinian Tube Wells are used when a temporary supply is wanted. These consist of tubes screwed one over the other and are commonly 20 to 25 feet deep. To construct one make a hole in the soil about 4 to 5 feet deep and hammer the first part of the tube which has a perforated steel point at its lower end. Drive these tubes into the soil one length being screwed on to the other. When the subsoil water is reached fix a pump to the tube and draw out the first portion till clear water is available.

The sandy bed of an old river is an ideal place for such wells as hard rocks prevent the tube from being driven down. Difficulties arise when sand and clay block the lower part of the tube and its openings.

Although these tube wells are somewhat superior to the surface wells, the same objections may be urged against them as they do not go down deep. The place should be free from all pollutions and not close to a stream. These wells are very useful where a temporary water supply is needed as during fairs (*melas*), or expeditions. They were employed with very satisfactory results at the Kathihar Plague Observation Camps, and during the recent Abor Expedition and are now being widely used in the Rangpur District.

Area drained by a Well.—This is nearly always four times the depth of the well and may be even more. Roughly, a well drains an area around it which may be regarded as an inverted cone the apex being represented by the bottom of the well. If a shallow well be hard pumped the distance drained may exceed the above area. It follows, therefore, that if there be any source of pollution within this area contamination will inevitably occur. This draining will depend on the nature of the soil and amount of depression of the water level due to pumping. Care should, therefore, be taken to select a site where any such contamination is impossible, and the distance of the well from such polluting source should be 100 to 160 times the difference in the level of the water in the well that might possibly be produced by hard pumping.

Sources of Pollution:—The following are the principal sources:—

(1) *Cesspools, privies and other collections of filth* nearabout. Connection may be established after a sudden rise in the subsoil water or by percolation. (Fig. 1.)

(2) *Rivers.*—By direct connection dirty water may gain access to a well.

(3) *Graveyards*, especially when subsoil water comes up to the level of dead bodies.

(4) *Cracks* or *fissures* in the soil which may result from an earthquake.

(5) *Trees* by sending roots down may help in admitting surface water into wells.

(6) *Rat holes* near about the well.

To ascertain whether a well water is polluted and the source through which the polluting material reaches the well, solutions of common salt, lithia salts, alkaline solution of fluorescin, paraffin oil or an emulsion of *bacillus prodigiosus* are employed. These when introduced into drains, cesspools or other supposed sources of mischief may be found in the well water, if the suspicion be correct, by virtue of their colour, taste or chemical properties even though largely diluted.

It may be observed that a highly contaminated water gets cleared and deprived of its suspended organic matters during its passage to a shallow well. The appearance of the water under such conditions becomes deceptive but nevertheless, it retains its dangerous properties. The sparkling appearance and palatability is due to dissolved CO_2 gas. Polluted water of shallow wells is hard and, therefore, unfit for domestic uses.

Examination of Wells.—In examining a well the following points deserve attention :—

(*a*) Any source of pollution within 200 to 300 feet of the well.

(*b*) Whether any adequate or proper coating lines the sides of the well or whether there are cracks or fissures on the sides.

(*c*) Depth of the well.

(*d*) Depth of the water in the well.

(*e*) Nature of the soil in which the well is sunk.

(*f*) Purposes for which the well is used.

(*g*) Average quantity of water daily drawn.

(*h*) Habits of the people using it.

(*i*) The way in which the waste water is disposed of.

(*j*) Whether there has been any recent rain, if so, its nature during the preceeding month.

The **yield** of water from a well can be determined by pumping water out to a certain level and noting the length of time required in its regaining the original level.

Ideal Well.—An ideal well should satisfy the following conditions :—

1. It should always be sunk in a good soil.

2. It should always be lined with some impervious material, and the water should come only from the bottom. The joints should be made watertight if lined with pipes.

3. The surrounding area at the top should be so sloped as to allow water to drain off readily.

4. It should be provided with either a pump, or a bucket and chain or rope, and no other vessel should be allowed for drawing up water.

5. The upper part of a well to a few feet all round the opening should be made *pucca* so as to convert it into a platform with a proper slope. No washing of clothes should be permitted there.

6. All rat holes, hollows and foul tanks near about should be filled up and adjoining trees cut down.

7. The top of every well should have a suitable covering with openings for ventilation.

8. It should be at a considerable distance from any sewage farm, or trenching ground, and at least about 250 feet from any human habitation or *bustee*.

Cleansing of Wells.—All wells should be thoroughly cleansed at least once every six months, but before doing so a light or a burning candle should be lowered down to ascertain the amount of carbon dioxide present inside the well. If the light goes out the inference is there is enough CO_2 to kill a person. Cleansing is best done at the close of the hot season when the water remains at its lowest level. The water of a well which has neither been used nor cleaned for sometime contains a large amount of organic matter and should therefore be first cleaned before using.

VI. **Tanks :**—Tanks are good sources of water supply if free from pollution ; but they are commonly made foul by being used for washing and bathing purposes, by the passage of excrement direct into the water, and by rotten leaves and other impurities. There should be very little chlorine in tank water. Presence of chlorine, nitrite and ammonia makes the water suspicious.

Tanks for drinking purposes should satisfy the following conditions :—

(*a*) They should be large, of a regular shape and deep, so that the subsoil water only may find its way in.

(*b*) Banks should be nicely sloped and covered with grass, and the edge or shore higher than the level of the surrounding land.

(*c*) They should be fenced in or enclosed by railings, and trees may be planted at a fair distance to keep away dust.

(*d*) No bathing nor washing of clothes or utensils should be permitted.

(*e*) Arrangements for drawing water from a platform or jetty should be made and no one allowed to get into the water.

(*f*) They should always have fish especially of the smaller variety which by feeding on mosquito larvæ and other impurities help to keep the water pure.

(*g*) No fishing or rowing should be allowed.

(*h*) Weeds should be removed as soon as they are grown, and the tank emptied and re-excavated once every five to ten years.

(*i*) There should be no cesspit or any source of pollution within about fifty feet and no houses in the immediate neighbourhood.

Except when the precautions given above can be strictly observed tank water for drinking purposes should not be used.

VII. **Rivers and Streams :**—Where the flow of water in a river is enormous compared with the volume of polluting matter entering, and the water is impounded in reservoirs for subsidence, and the clarified water is finally subjected to most careful filtration, a good potable water may be the result.

The danger of pollution is from sewers, sewage, manuring cultivated fields, and trade effluents. Water from large streams if properly looked after is a good water for town supply. Towns, as a rule, draw their water supply from a river above the spot where the sewage of the town is discharged. Larger rivers are able to get rid of a moderate amount of sewage pollution by the combined agencies of oxidation, vegetation and bacterial action.

It may be observed that streams and rivers in their course through cultivated areas, towns and villages often get polluted particularly near the banks, and, therefore, such waters should be looked upon as unsafe for drinking purposes. When contaminated with sewage they usually contain specific micro-organisms as of cholera or typhoid fever. Water from the centre of big Indian rivers, *e. g.*, the Ganges, is satisfactory. According to Hankin "the water of the Ganges and Jumna is hostile to the growth of cholera microbe, not only owing to the absence of food materials, but also owing to the actual presence of an antiseptic."*

Water for drinking purposes should therefore be collected from at least 20 to 30 feet beyond the shore. This may be done by means of a small boat tied to a post or anchor, or by having a sort of jetty-like arrangement, or by means of a pipe attached to a hand pump. Deep water is always better. In India many rivers remain dry for a greater part of the year and the water can be impounded by erecting a high dam across the bed of the river and thereby directing the stream to settling tanks.

When the supply is drawn from a river the following precautions should be observed :—

(1) There should be no villages within 10 miles of the intake.

(2) The point of intake should not be permitted to be polluted in any way as by fishing or anchoring boats or ships, &c., and should not be influenced by tide.

VIII. **Distilled Water** :—*Distilled water* is generally resorted to on ship board and is often obtained from sea water. This is usually flat and not very palatable, and should, therefore, be ærated before using. Distilled water should never be stored in zinc, lead, or copper vessels.

---

* Preface to his work on *Cholera* 5th edition

STORAGE AND DELIVERY OF WATER.

Good drinking water should be perfectly clear, free from taste or smell, cool, well ærated, palatable and fairly soft.

Storage of Water.—It is generally necessary to store water, but the methods vary with the source. In upland surface schemes storage is usually made by impounding the water. Large towns like Calcutta are often divided into districts, each of which has a service reservoir. This system has an advantage : in case of disorder or waste in one district other districts do not suffer in consequence thereof.

In the case of water supply of a town or a city it is necessary to provide large storage reservoirs the capacity of which should be such as to hold a week's supply at least and should be cleansed twice or thrice a year. In Calcutta the water is stored in an elevated reservoir. It is a huge structure 320 ft. square, and 16 ft. deep, standing on a network of steel, the pillars of which are 90 ft. high. It covers an area of two and a third acres, and the total weight when full of water is about 72,000 tons, the water alone weighing 53,000 tons. For small communities, such as prisons or asylums, deep wells are good. In villages and rural districts shallow wells and tanks are often the only sources of supply. In India reservoirs and cisterns should be protected from the sun, and well covered and ventilated.

Action of Water on Lead :—The kinds of water which affect lead most are the best and worst waters.

The following kinds of water act on lead :

(1) The purest and most highly oxygenated water, as rain and upland surface water.

(2) Water containing nitrates or nitrites (sewage and animal matters) or chlorides.

(3) Water from peaty soils containing acids, as humic acid.

(4) Neutral distilled water.

(5) Muddy river water.

Water containing one tenth of a grain of lead in a gallon is unfit for drinking purposes. Filtration through charcoal will remove lead from water.

Waters least likely to affect lead are :—

(1) Hard water containing sulphates, carbonates and phosphates of calcium forms a coating of insoluble carbonate of lead in the interior of the pipe which prevents further action.

(2) Hard water containing carbonic acid gas under pressure would dissolve a small amount of carbonate of lead. This explains cases of lead poisoning from soda water.

(3) Water containing soluble silica deposit, silicate of lead being insoluble in water.

Distribution of Water.—In Indian towns filtered water is usually delivered by means of iron pipes laid underground. But to avoid erosion particularly when the water is soft these are coated either with Angus Smith solution, or vitreous glaze to protect them from the injurious effect of water. In Calcutta distribution is carried on by steel pipes $\frac{3}{8}$th inch thick coated with a special asphalt preparation and having a diameter of 5 to 6 feet. In houses lead pipes are used as they are easily bent and fitted and comparatively cheap. These are connected with the main by means of brass ferrules.

For many purposes for which water is used it is not absolutely necessary that the water should be pure. Where the demand is great as in large towns like Calcutta, and owing to a deficiency in the amount of pure water available, there is a dual system of supply, the impure or unfiltered water for flushing sewers and water-closets, watering roads, extinguishing fires and manufacturing or trade purposes, and the pure for drinking and cooking purposes only. With this dual supply the amount of pure water required is greatly lessened. In villages this double supply is very commonly met with. The well yields water for cooking and drinking purposes, whereas a neighbouring stream, tank or pond furnishes water for washing, bathing, &c. There can be very little objection to such a procedure in villages, but in towns a dual supply necessarily involves a second system of mains and supply pipes, and very often impure water will be used for drinking purposes and may thus be a factor in spreading epidemic diseases.

Water supply in towns may be either *intermittent or constant.* In many towns for the sake of economy the supply of water is intermittent. In theory this method appears economical, but in practice it leads to little, if any, saving. The intervals during which the mains and service pipes remain empty, foul air and polluting matter from sewage-charged soil or drains are liable to be sucked in through imperfect joints or decaying pipes. Larger house cisterns have to be provided for storage of water which is often wasted. There is further the risk of contamination. and as the whole day's supply has to be furnished in a few hours, larger mains are necessary. In cases of fire water may not always be available.

PROPERTIES AND IMPURITIES OF WATER.

Properties of Water:—Water is a clear, transparent, tasteless, and odourless liquid. It freezes at 0° C. or 32° F. ; when it freezes it increases in bulk by one eleventh of its original size. Its greatest density is at 4°C., it is very slightly compressible and boils at 212° F. or 100° C. under a pressure of 760 mm. when it is converted into more than 1600 times its own volume of steam. The boiling point varies according to pressure, and at Darjeeling it is 96° C. It is a chemical compound, consisting of two volumes of hydrogen and one of oxygen.

Impurities of Water—According to Parkes, the origin of impurities may be from :—

(*a*) *Substances received at the source.*—The character of the water will depend upon the geological structures through which it has travelled. Presence of calcium or iron will produce hard water as in chalk wells. Water from neighbourhood of graveyards contains organic impurities. Likewise, water from wells in town or densely populated place often contains calcium, sodium, nitrites, nitrates, sulphates, phosphates, &c.

Water, either in wells, or tanks may often get contaminated by soakage and washings. In India the tank water is very often contaminated by washing clothes in or near the tank and the passage of excrement directly into it. A village tank therefore is a great source of danger, and a strict eye should always be kept on such a water.

(*b*) *Impurities derived during transit from source to reservoirs.*—Open conduits like rivers, canals, &c., are liable to be polluted by sewage, house and waste water, manufacturing refuse, &c. Purification, however, goes on during its flow by means of subsidence, by the action of normal water bacteria on pathogenic micro-organisms and by the presence of aquatic plants.

(*c*) *Impurities from storage.*—When water is obtained from a tank or well or in a town where the supply is intermittent, it is necessary to store water for drinking purposes, but the method of doing so is by no means unimportant, for however carefully the water might be stored it often deteriorates, and by losing its sparkling character slowly becomes flat and insipid.

In this country water is ordinarily stored in *ghurras*, wooden tubs or metal vessels and masonry tanks (*choubachhas*). When stored in metal vessels and protected by a cover the water, although loses its ærated character, remains pure. *Sarais* and other earthen-ware vessels have the advantage of keeping the water cool and sparkling, but being porous they take up dirt and may therefore contaminate the water. Further, these receptacles are very often kept under staircases, landing floors and other insanitary places where accidental contamination from dust, dirt, cockroaches, &c., may occur.

(*d*) *Impurities of Distribution.*—Lead and other metals are dissolved by certain waters, and if the pipe is occasionally left empty, as happens when the supply is intermittent, sewage and impure air may be drawn into them. This may be prevented by laying the water mains at a distance from gas pipes, drains or sewers, and on a solid basis so as to prevent any cracks occurring from subsidence.

When distribution of water is by hand or by *bhistis* (water carriers) in *mussaks* or leatherbags, which can hardly be kept clean, the chance of contamination greatly increases. These water carriers as a rule live under insanitary conditions and the *mussak*, if once get infected, will act as a means for spreading the contamination. This method of transport of water should, as far as possible, be discountenanced, and for drinking purposes such a water must first be boiled and filtered.

EFFECTS OF IMPURITIES OF WATER.

Contaminated water is often used for a lengthened period without giving rise to any appreciable effect on the consumers, and it is very probable that in many instances the system becomes habituated to its use. For, not infrequently, we find persons who have previously used pure water suffer from some trouble when they are made to drink such a polluted water, which the old inhabitants of villages prefer drinking to a purer supply. But impurity to a certain extent is practically inevitable and is neither disagreeable to the taste nor injurious to the health. An absolutely pure water is insipid and perhaps unwholesome. A good water is not one which is chemically pure. Transparent, colourless, odourless, tasteless water with no suspended matter or excess of total solids; but with sufficient dissolved air, is all that is wanted.

Specific pollution is very likely to occur in water and disease generally follows :

I. **Effects of Vegetable Impurities.**—Putrid or decaying vegetable matters may give rise to diarrhœa, and dysentery in the tropics and other severe symptoms to persons unused to it.

II. **Effects of Mineral Impurities.**—Suspended mineral matters or an excessive quantity of magnesium sulphate or chloride may cause irritation and set up *diarrhœa*. *Sprue* is not an uncommon complication in certain parts of India, and it has been ascribed to fine particles of mica in suspension.

Goitre.—The evidence with regard to the true nature of goitre-producing substance is conflicting. It has been ascribed to the presence of magnesium salts in water. It occurs in epidemic form in Gilgit and Chitral valleys.

Plumbism.—This may result from a continued use of water containing lead. This metal is very seldom found as a normal constituent of natural water, but very soft waters act on lead pipes, cisterns, &c. Individual susceptibility of persons to the action of this cumulative poison varies. One-tenth of a grain per gallon has been known to produce ill effects.

Zinc is occasionally found in water, and soft water which acts on lead will also dissolve a certain amount of zinc from the surface of galvanised iron. Obstinate *constipation* may result from consumption of such water.

Iron is not infrequently found in water and gives rise to dyspepsia.

III. **Effects of Animal Impurities:**—This is most important from the hygienic point of view. Water polluted with fæcal excreta specially of persons suffering from enteric fever or cholera is very dangerous.

Cholera.—Water plays a most important part in the spread of this disease. In India the villages on the banks of the rivers are specially affected. Outbreaks also occur in a village when the tank or well, which supplies the people with drinking water, becomes infected. Epidemics are not uncommon in a pilgrimage or after a bathing festival. In Calcutta it has been largely reduced by the introduction of filtered water supply, and in Madras the mortality has come down to a quarter within ten years.

Typhoid Fever.—This is propagated through water infected by the urine or fæces of patients who are suffering or have suffered from typhoid fever.

Similarly *Dysentery* and *Enteritis* may result from the drinking of infected water.

Malaria.—Since water is essential for the breeding of anopheles, malaria may be caused only indirectly.

Entozoal Diseases.—Diseases due to Distomum hepaticum, Ascaris lumbricoides, Filaria sanguinis, Ankylostoma duodenale, Oxyuris vermicularis, &c., may be contracted by drinking water containing ova of these parasites.

Insufficient water supply leads to impurities of all kinds and as such to disorders and diseases. Skin affections and ophthalmia may also be due to the same cause. Deficient supply of water, besides causing distressing thirst, lowers muscular strength and mental vigour.

PURIFICATION OF WATER.

Public water supply should be of such a nature as not to necessitate further purification by its consumers. Water derived from carefully protected springs or deep wells requires no such treatment, but in the case of surface water, river water, or water from any source liable to sewage contamination, purification becomes necessary. By this we not only remove suspended matters, excessive hardness, specific micro-organisms, but also make the water palatable and sightly.

Impure water may be purified by either of the following methods :—

A. Natural.

B. Artificial.
- I. Physical
  - *a.* Distillation
  - *b.* Boiling
- II. Chemical
  - *a.* Precipitation
  - *b.* Germicides
- III. Mechanical (filtration)

A. Natural Purification of Water.—This is only possible in case of rivers, streams or where there is a large volume of water; for, as soon as any sewage or polluting matter is discharged it becomes diluted, and the dissolved oxygen through the agency of ærobic bacteria oxidises to a certain extent the organic materials of the sewage, and consequently absorbs more oxygen from the air to replace this loss. Aquatic plants give off oxygen, and unless these are destroyed by sewage further oxidation occurs. Moreover, fish and other lower forms of animal and vegetable lives help the purification by feeding on these organic impurities, and if the current is sluggish the suspended matters settle in the bottom. Indeed Delépine has shown that this sedimentation is an important factor in the bacterial purification of river water. Further, solar rays aid materially in the purification of such water. Yet of greater importance is the evidence of destructive changes accompanied by loss of virulence of certain organisms particularly those of "intestinal type" which undergo in rivers and stream waters. These organisms are *B. Coli*, *B. Enteritides Sporogenes*, &c. It seems probable that water is not the natural habitat of pathogenic bacteria as of cholera and typhoid fever. In the struggle for existence they have to fight against the saprophytic bacteria naturally present in water.

B. Artificial Purification of Water:

I. Physical Method or Sterilization of Water by Heat.—There are two ways of doing this :—

(*a*) *Distillation.*—This is generally done on board the ship. It is not practicable to do this on a large scale. Distilled water is not very palatable. It acts readily on such metals as copper, zinc, iron and lead.

(*b*) *Boiling.*—By this means certain micro-organisms and their spores are destroyed, the temporary hardness of water is removed by the precipitation of calcium salts, and ammonia and sulphuretted hydrogen gases are given off. For all practical purposes bringing to the boil is sufficient, and the water should afterwards be kept in a closed vessel. Boiling makes the water very flat and insipid, and should therefore be ærated before drinking.

II. Purification by Chemical and other Agents:

(*a*) *Use of Precipitants.*—By this a precipitate is formed which entangles and carries down suspended matters and micro-organisms. The following are the different methods :—

(1) *Softening of Water.*—A hard water is that in which calcium and magnesium salts are held in solution in the form of carbonates and sulphates. When the hardness is due to the

presence of carbonates kept in solution by carbonic acid, it is known as *temporary*, as the hardness is removed by boiling which drives away CO_2 gas and thus precipitates the carbonates. When the hardness is due to the presence of sulphates and not removed by boiling it is called *permanent*. Permanent hardness is removed by the addition of milk of lime (lime water), or soda ash. The alkali combines with CO_2 and calcium carbonate is thrown down.

With soda ash the sulphates are decomposed as under:—

$$CaCO_3,CO_2+CaO=2CaCO_3$$

$$MgSO_4+Na_2\ CO_3=MgCO_3+Na_2SO_4$$

The carbonates fall down to the bottom and during the process of softening certain amount of bacterial purification is also effected.

(2) *Alum.*—This acts if the water contains calcium carbonate. It produces copious flocculent precipitate of calcium sulphate and aluminium hydrate which fall to the bottom. The usual quantity required is 6 grs. to a gallon. Certain vegetable albuminous matters are also removed by this means.

(3) *Perchloride of Iron.*—2½ grs. to a gallon will purify water from its suspended organic matter and clay.

(4) The fruits of *Strychnos Potatorum*, commonly known as "clearing nut" (*neermuli*, vern.) is often used in India to clear muddy water. One of these fruits is well rubbed for a minute or so in the middle of the vessel containing the water which is then left to settle. In a very short time the impurities fall to the bottom leaving the water clear and perfectly wholesome. Before the introduction of filters in the army, the officers and soldiers used to carry these seeds to purify their water.

(*b*) *Germicides.*—The following are the common germicides used to purify water :—

(1) *Potassium Permanganate* acts mainly as a germicide by destroying the organic matter on which bacteria thrive, and, therefore, is of very great value in treating infected wells, tanks or other waters in times of epidemics of cholera. Add enough of the salt till the water becomes faintly pink.

(2) *Copper sulphate* is useful for removing algæ and other vegetable growths in tanks. Solution of 1 in 100,000 is necessary to be of any use. The simplest way to ensure a thorough diffusion of the reagent is to put them in linen bags attached to ropes or strings and then drawing about the water to be treated.

(3) *Nesfield's Tablets.*—A two grain tablet of iodide-iodate of soda and a same quantity of citric acid is added to four gallons of water, and it is claimed that cholera and enteric organisms are killed in a few minutes.

It should be observed that the above methods of purification of water are anything but satisfactory. Efficient filtration or boiling is far safer and is therefore recommended for general use. In countries where filtered water supply is not available, boiled water may safely be used for drinking purposes.

III. **Filtration.**—The object of filtration is to remove the impurities of water, specially the disease-producing micro-organisms. Sand and gravel are usually used as filtering media.

Filtration on a large scale is a system of sand filtration. The water, taken from such a portion of the stream where there is no source of pollution within a reasonable distance, is collected in *settling tanks* or large reservoirs, where sedimentation occurs, and most of the bacteria are destroyed by light and air. The time usually taken for the suspended matters to settle varies from 24 to 48 hours during the rains, but is less in other seasons. From these settling tanks the water is passed into what are called "filter beds." These are made up of gravel and sand and have perforated tubular drains below for the collection of filtered water.

The filter beds are rectangular in shape and are filled from below upwards with :—

(*a*) Two layers of *bricks* arranged in the form of channels for the passage of water, spaces being left between two bricks, which are covered by the second layer.

(*b* *Gravel* about 2 feet deep, of varying coarseness which increases from above downwards. This is covered by a layer of sand from 2 to 3 feet in thickness.

The effect of this filtration is chiefly mechanical, although a certain amount of biological action does take place. The real agent which separates the organisms is the layer of slimy organic matter formed upon the surface and in the interstices of the sand. This green slimy layer made up of fungi, algæ, and other low vegetable organisms, commences to appear after three days ; and therefore, the filter acts best after the third day when this jelly-like layer or membrane is formed. The bacteria get entangled and arrested by this gelatinous mass and so are prevented from passing down into the deeper layers of sand and gravel. Koch has shown that if this surface be removed by scraping, or its continuity affected in any way as by excessive and irregular pressure, the number of bacteria which pass through this purifying layer will increase considerably. When, however, this deposit becomes very thick and consequently impermeable, filtration becomes imperfect and the bed has to be scraped, washed and cleaned, but after this water should be allowed to stand till fresh membrane forms before filtration commences again ; therefore the first portion of the water should not be stored in the pure water reservoir For filtration to be efficient Koch considers that the movement of water through the sand layer should not exceed four inches per hour and the effluent from each filter should not yield more than 100 microbes per Cc. on gelatine plates and the thickness of sand should never be less than 11·8 inches.

An essentially bad water cannot be made good by any amount of filtration, therefore no attempt should be made to purify organically impure water for drinking purposes.

Domestic Filters.—For this purpose different materials such as animal or vegetable charcoal, silicated carbon, spongy iron, flannel, wool, sponge, &c., are used. Water filtered through animal charcoal favours the growth of microbes and deteriorates rapidly. The same remark holds good to the majority of substances just mentioned. Spongy iron is the least objectionable of all.

A domestic filter to be satisfactory must keep back all germs and the substances that are used for the purpose are some forms of infusorial earths, clays, porcelains or patent combinations of porcelain and clay.

The essential features for a good filter are:—

(1) It should be strong and compact and simple in construction to allow of easy cleansing and re-adjustment.

(2) It should be constructed of some stable and efficient material having the power to purify water to a high degree.

(3) The filtering medium should not require frequent charging and neither it nor the receptable should impart any thing injurious to the water.

(4) It should be cheap and its purifying power fairly lasting.

The following domestic filters are commonly used :—

1. *The Pasteur-Chamberland Filter.*—It consists of porous tubes or bougies of unglazed porcelain made of kaolin. These tubes can be screwed on to a tap. Its action is purely mechanical, as it separates even very fine particles of suspended matters and bacteria. Unless there is some pressure the filter acts slowly ; 20 to 40 pounds of pressure per square inch will filter about three quarts of water per hour. The candles should occasionally be cleaned by brushing in hot water or the whole thing may be boiled. It is a perfectly reliable filter, as it clears water of all bacteria. Muddy water should first be cleared by passing through closely packed coarse sponges and then filtered.

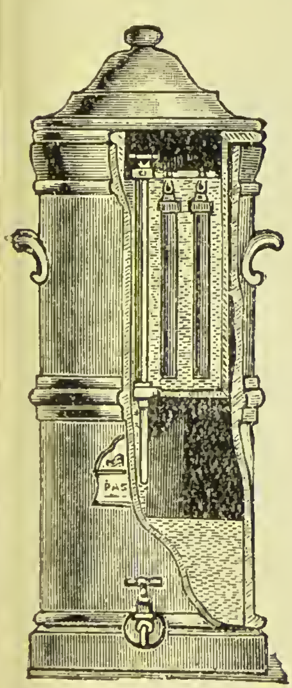

Fig. 2.

Pasteur-Chamberland Filter. Plate kindly lent by S. M. Dey & Co., Calcutta.

2. *The Berkefeld Filter.*—This consists of a cylinder made of infusorial earth. But the cylinder wears out thin by constant cleaning and gradually ceases to filter efficiently.

In order to secure a perfect protection from water borne diseases especially enteric fever the candle should be sterilized by boiling every third day. Muddy water, if not previously clarified by passing through closely packed coarse sponges, would clog up such a filter rapidly. The sponges should,

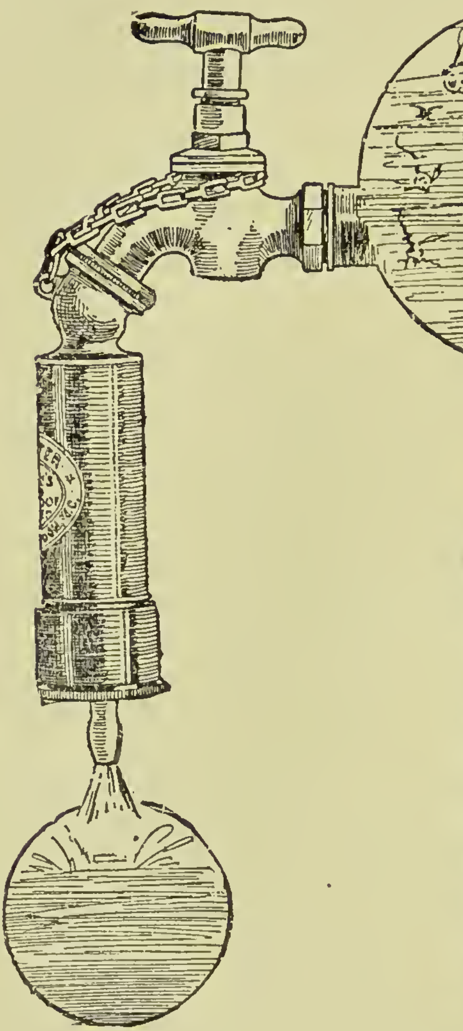

Fig. 3.

Berkefeld Tap Filter. The Filter is attached to an ordinary tap and its action is to hold back the micro-organisms in the water.

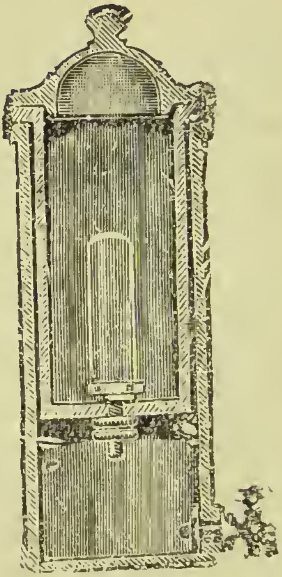

Fig. 4.

Berkefeld Filter. Plates kindly lent by Whiteaway Laidlaw & Co., Calcutta. Sole Agents for India.

unless the water be very muddy, be cleansed and sterilized once a week.

Of these two filters the Pastuer is more reliable and durable than the Berkefeld, but the one disadvantage which

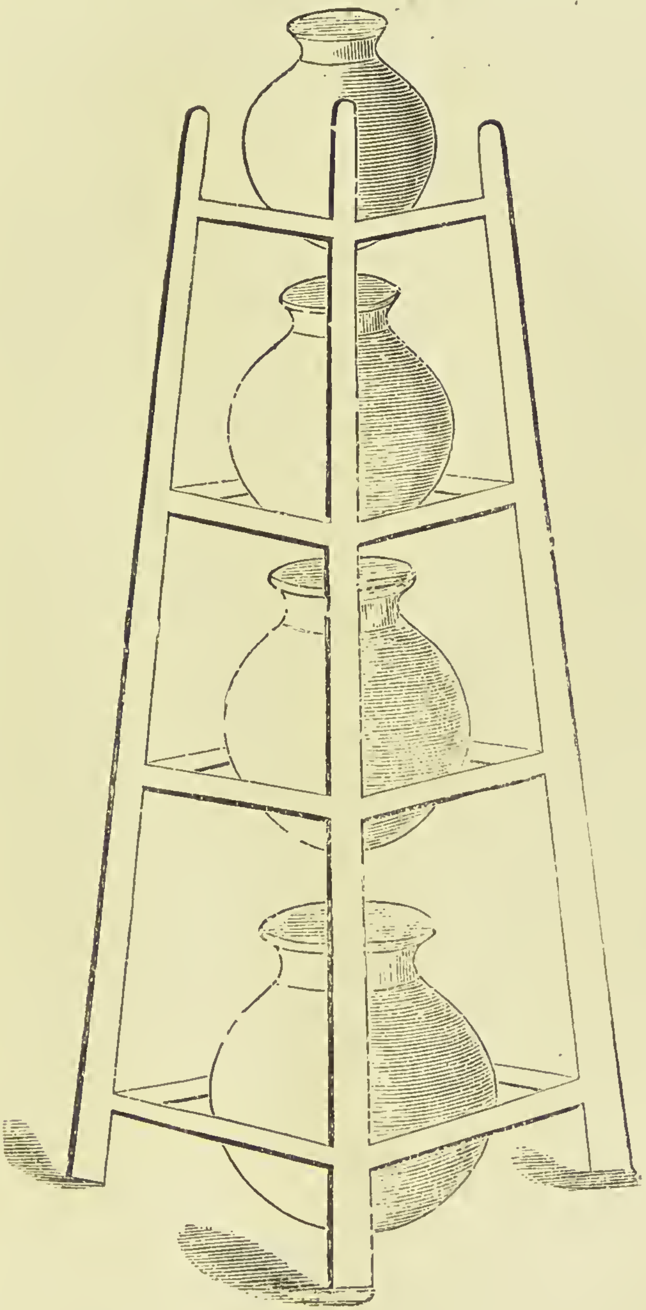

Fig. 5.
Four-Ghurra Filter.

may be urged against the Pasteur is that it filters very slowly and is practically useless unless the water is put under pressure. The Berkefeld, on the other hand, requires no additional pressure, which is undoubtedly an advantage, but the pores being more open the action of the filter cannot be very much relied upon. Being made of infusorial earth they are more liable to fracture.

3. *The four-ghurra Filter.*—This method of filtration is very popular in India and is resorted to by people living in villages. It consists of four unglazed earthenware pitchers placed one over the other on a wooden or bamboo frame, each one having one or more holes at the bottom stuffed with cotton wool or straw. The uppermost one contains the unfiltered water which is first boiled and strained. The second one is half filled with powdered charcoal, and the third one with fine sand and a layer of small stones underneath. The lowest one is the receiving vessel. The filtering media must be kept as clean as possible, and the charcoal should be renewed once every week or ten days, and the sand cleaned and dried once a month. This domestic filter acts satisfactorily if properly looked after.

The idea that filters do not require any attention or cleansing and that the filtered water is always above suspicion is erroneous. For the pores of the filter very often get clogged with foul materials which afford a suitable nidus for bacteria to flourish and the so-called filtered water becomes infinitely worse than the original one. This happens particularly when animal charcoal is used as a filtering medium.

EXAMINATION OF WATER.

For hygienic purposes examination of water is generally done under the following heads :—

A. Physical or macroscopic examination.

B. Chemical examination.

C. Microscopical examination.

D. Bacteriological examination.

Collection of Sample :—Take a clean Winchester quart bottle of white or pale green colour with a stopper or a perfectly new and clean cork. Rinse it three or four times with the water to be examined. If the sample has to be taken from a stream, lake or a well, the stopper should be inserted and the bottle placed well under the surface of the water before it is filled. In rivers take it from the mid-stream or from a reasonable distance from the shore. In towns the sample should be taken from the mains or stand posts or taps. When collecting from a tap, allow the water to run for a few minutes before taking the sample. Fill the bottle quite full and replace the stopper which will make room for itself.

No sealing wax or grease should be applied to the stopper. It is best secured by a covering of clean linen or by an india rubber cap and then sealed.

Apply a label with particulars.

The bottle should be kept in a cool dark place, in an ice box if possible. The examination should be undertaken as early as possible after the collection of the sample.

The following informations should always be furnished with the sample of water:—

(*a*) Source of water, *i.e.* whether from tanks, or wells, &c.

(*b*) Geological formations of the neighbourhood; so far as known.

(*c*) Depth, diameter, strata through which sunk, how used, and depth of water, in case of a well.

(*d*) Possibility of impurities reaching the water; in case of a well its distance from cultivated land, cesspools, drains, privies, &c.

(*e*) Method in which the water is stored in case of surface or rain water.

(*f*) Meteorological conditions, whether there had been any recent rain or flood.

(*g*) A statement of any existing water borne disease in the neighbourhood, or special reasons for requiring analysis.

Each bottle should be distinctly labelled to correspond with the official letter or invoice.

For bacteriological examination either a sterile stoppered bottle or a hermetically sealed flask should be used. In case of a flask break the sealed end in the water when the water will make its way in. Take it out and seal it again. In every case of bacteriological investigation the examination should be made as early as possible after the collection of sample. About two to four ounces of water is usually necessary for such an examination.

A. **Physical Examination of Water.**—This by itself cannot form a basis of opinion, but brilliant, clear, non-smelling, and highly ærated water is alone fit for human consumption.

Note the following:—

(a) *Colour.*—Pour the water into a colourless glass tube about two feet deep placed on a white plate and note the colour. The longer the tube the better is the colour noticed. Pure water has a bluish or greenish tinge. Yellow or brown colour generally indicates contamination with animal organic matter mainly sewage, but may also be due to vegetable matters or salts of iron.

(b) *Clearness.*—Shake a small quantity of water and note whether it looks hazy or not. Heavy sediments rapidly fall to the bottom.

(c) *Lustre or brilliancy.*—Some water is distinctly dull or of slimy appearance. Clear and sparkling water contains CO_2 and air.

(d) *Taste.*—Water that tastes bad should be rejected.

(e) *Smell.*—Smell of hydrogen sulphide when heated to boiling indicates contamination.

B. **Chemical Examination of Water:**

(a) *Reaction.*—This is taken with a litmus paper, or by dropping a solution of Phenolphthalein which when added to water having the faintest trace of acid will turn it delicate pink. Acidity may be due to humic acid or CO_2, if due to the latter it will disappear on boiling. Alkalinity may be due to ammonia, which may similarly disappear when the water is boiled. But permanent alkalinity is due to the presence of sodium, calcium, or magnesium carbonates in solution.

(b) *Hardness.*—A certain amount of hardness is removed by boiling. "Total hardness" is that which is present before boiling and that which remains after boiling is called "permanent hardness" The amount of hardness is generally expressed in degrees. Clarke's soap test is employed in determining the amount of hardness. This consists of a solution of soft soap in a mixture of methylated spirit and distilled water in the proportion of 4 and 6 respectively.

To determine Total Hardness.—Take 100 Cc. of water into a stoppered bottle, to this add soap solution from a burette with constant shaking till a sufficient lather is produced. The number of Cc. of soap solution used minus 1 gives hardness per 100,000 parts.

Permanent Hardness.—Boil 150 Cc. of water for 15 to 20 minutes and add distilled water from time to time to make up the loss by evaporation. Allow it to cool and add distilled water to make it up to 150 Cc. and filter off 100 Cc. The hardness is estimated as above.

Temporary Hardness.—The difference between the total and permanent hardness is the temporary hardness.

According to Clarke's test each degree corresponds to the soap destroying power of 1 gr. of $CaCO_3$ in 1 gallon of water. When it is less than 10 degrees the water may be considered soft or moderately soft, when 10 to 15 degrees moderately hard, when 15 to 20 degrees hard and over this figure very hard.

(c) *Chlorides* are always present in small quantities in all waters except distilled water, and give a white precipitate with a solution of nitrate of silver. These are derived from sea water or sewage (urine) or from salts in the soil. It is impossible to draw any inference as to sewage contamination from the presence of chlorides alone unless one knows how much of known purity is contained in water from the same source. Although sodium chloride is found in the urine, considerable pollution must take place before it can be detected by an increase of the chlorides. The permissible limit of chlorides is 1·5 parts in 100,000 ; roughly when the salt is not in such a quantity as to be appreciable to the taste it may be considered harmless.

(*d*) *Nitrites.*—The presence of nitrites is an indication of recent contamination of sewage undergoing decomposition ; therefore water containing nitrites should always be condemned. Their presence is detected by adding to a little of the sample dilute sulphuric acid and a few drops of metaphenylinediamine, when almost immediately a yellow colour is produced.

(*e*) *Nitrates.*—Nitrates are the ultimate products of oxidation of all animal matters. If nitrates are large in amount and nitrites and ammonia are small, the import is that the water has been contaminated before and the ultimate product is left behind, or the contamination occured above the point of taking water. Presence of nitrates indicates that the contamination is of long standing. The permissible limit of nitrates is from ·5 to ·35 parts per 100,000. The nitrates and nitrites are never present in raw sewage, and if they are found with excess of chlorine and ammonia it means that the water has been contaminated with sewage or animal refuse.

Test.—Evaporate a little of the water and to the residue add a drop of H_2SO_4 and a little brucine when a pink colour is produced.

(*f*) *Ammonia* is detected by adding Nessler's solution which gives a yellow or brown colour according to the amount present in the water. Sewage and manurial matter yield free ammonia on distillation, but by the action of alkaline solution of potassium permanganate on the albuminous matter a further quantity of ammonia may be detected. This is called *organic or albuminoid ammonia*, as distinguished from *free or saline ammonia*. Traces of ammonia may be detected in almost all waters, specially rain water ; therefore, its presence alone cannot be taken as an indication of animal pollution. Besides this, water which has been stored for sometime in metal vessels will yield ammonia due to the reduction of nitrate by the metal (as zinc, iron, lead). But in these cases traces of metal can be detected. These impurities absorb much oxygen from acid solution of potassium permanganate, called "oxygen absorbed." The amount of free and albuminoid ammonia and of "oxygen absorbed" should be considered together in forming an opinion as to the purity of water.

Tests.—(i) *Free Ammonia.*—Place 250 Cc. of water in a boiling flask and distil over 50 Cc. The amount of ammonia is determined by the process of 'Nesslerisation,' which consists of adding to the distillate 2 Cc. of Nessler's solution; and imitating the depth of colour produced by adding Nessler's solution to pure distilled water to which definite quantities of solution of ammonium chloride has been added. The water remaining in the retort is used in the test of—

(ii) *Albuminoid Ammonia.*—Distil over another 50 Cc. and pour into the distilled water bottle. Add 25 Cc. of alkaline potassium permanganate solution and distil off two 50 Cc. Nesslerise as before.

The amount of ammonia obtained in the above two experiments multiplied by ·4 gives the ammonia in 100,000 parts of water.

(*g*) *Iron.*—Yellow prussiate of potassium with dilute hydrochloric acid gives a blue colour with iron salts.

(*h*) *Lead and Copper.*—Ammonium sulphide produces a black colour.

(*i*) *Total Solids in Water.*—Take a known quantity of water, say 10 Cc, and evaporate to dryness on a weighed porcelain dish. Weigh the dish with the residue and the increase in weight is the weight of the solids. White incrustation indicates mineral while charring animal or vegetable matter.

C. **Microscopical Examination of Water.**—This is best done by centrifugalising the water when all its suspended matters fall to the bottom of the tube. The grosser matters, as clay or sand are easily recognised by boiling the water when they sink rapidly to the bottom. Sediments can also be obtained by allowing the water to stand for sometime in a conical vessel. Suspended sand or clay gives a yellowish white turbidity, sewage generally a light-brown, and vegetable matters or peat a blackish colour. The presence of spores or mycelia is due to contamination with sewage, and the most suspicious elements are the remnants of vegetables used for food, *e.g.*, spiral cells of cabbages, cauliflowers, &c. Detection of these cells, as also fibres of cotton, linen, wool, hair, starch granules, &c., can best be made under a microscope. Presence of a large number of parenchymatous tissues, spiral cells, and yellow elastic tissues indicates contamination with fæces. Animal substances, *e.g.*, wool, hair, yellow elastic tissue, &c., generally indicate recent contamination, while sarcinæ ventriculi, a kind of algæ growing in the stomach, point to sewage contamination.

D. **Bacteriological Examination of Water.**—This is best carried out in a bacteriological laboratory. To determine the number of colonies and specific micro-organisms mix a small quantity of the water with sterile agar or gelatine melted over a waterbath. The mixture is then spread in a thin layer on a petri-dish and allowed to solidify. Keep it in an incubator for about forty eight hours when the bacteria grow and form' 'colonies" dotted over the plate. These are recognised by their appearance, size and by making sub-cultures.

CHAPTER II.

AIR.

Air was the name formerly given to all gaseous substances, but the name is now restricted to atmospheric air—the air we breathe—the invisible elastic fluid which surrounds the earth extending to an unknown height. Long before the composition of the atmospheric air was explored, or the researches of Lavoisier, Priestley and others explained the chemistry of respiration, the importance of atmosphere, as a medium through which health could be affected, was present in the minds of the physicians.

Pure air is absolutely necessary, for healthy life and perfect health can only be maintained when in addition to other requirements there is an abundant supply of pure air. Every one is aware that while starvation kills after days, deprivation of air takes but a few minutes. Health and disease are in direct proportion to the purity or otherwise of the air. Increase in the amount of ill-health being largely due to impurities of air.

Composition of Air.

Air is a mixture and not a chemical compound, and its composition is practically constant. This uniformity of composition is due to diffusion, constant movement by means of air currents and reciprocal action of animals and plants on air.

The following is the approximate composition of air :—

Oxygen ...	... 209.6	per 1000 volumes.
Nitrogen ...	... 790.0	do
Carbonic acid ...	... 0·4	do

Watery vapour	... varies with temperature.
Ammonia ...	... trace.
Organic matter ...	... variable.
Ozone ...	
Salts of sodium...	
Other mineral substances	

Pure air is colourless, tasteless and odourless. *Nitrogen* forms 79 per cent by volume and 76·9 per cent by weight. Another most important body forming about 1 per cent of the nitrogen of the air is *Argon* having an atomic weight of 39·8 and discovered recently by Raleigh and Ramsay. *Oxygen* is the most important constituent of the air and is absolutely necessary for life and combustion.

Ozone.—In popular language this is known as "condensed oxygen," $3O_2=2O_3$. It is found in very minute quantities, if at all, in the atmosphere of towns. Its chief source in nature is atmospheric electricity, and is also partly derived from evaporation of large masses of water. Hence ozonised air is abundant in the sea-coast. Some observers hold that it is increased in amount in the neighbourhood of pine forests. The readiness with which it parts with its extra atom of oxygen makes it of special value from a hygienic point of view, for by this action it renders organic effluvia innocuous. It is recognised by its peculiar odour, and by its turning blue a piece of blotting paper moistened with a solution of potassium iodide and starch. It is non-cumbustible and slightly soluble in water.

Carbon Dioxide.—The chief sources of carbonic acid in the air are respiration, fuel combustion, decomposing animal or vegetable matter, volcanic and other allied phenomena. Along with the production there are other means of its removal from the atmosphere. It has been stated that chlorophyll of the plants has the property of fixing carbon and liberating oxygen to air. According to Schulze the sea plays an important part in the regulation of the carbonic acid of the air, and Fodor considers that the soil is the chief regulator. The wetted surface of the soil either absorbs it from or restores it to the air according as the gas is present in greater or less quantity in the atmosphere. Being a direct result of combustion, CO_2 is found in considerable amount in big cities and towns.

Ammonia.—Ammonia and its salts are always present in the air in small quantity. The amount of ammonia present in the air is an indication of decomposition of animal matter taking place on the surface. Its amount diminishes after rain which dissolves it. Plants derive some of the nitrogen for food from this source.

Organic and Suspended Matters.—These consist of minute particles of mineral matters (common salt, specially near the sea), soot and dust, bacteria and their spores, vegetable debris, &c.

Moisture.—This is always present in the air, but is subject to great variations, the amount however depends on temperature. There is more watery vapour in the tropical atmosphere than in temperate and cold climates, more at sea than on land, greater in summer than in winter, and at midday than in the morning and evening. Water has an important influence on the health either directly or indirectly. The evaporation of the moisture from the skin is the great regulator of the temperature of the body and if the quantity of water vapour in the atmosphere is great, this is interfered with. An excess of moisture is an important cause of the harmful effects of hot climates.

Physical Properties.—Air has weight; this is proved by weighing a glass bulb first with air exhausted and then with air filled. The difference in weight gives the weight of the air. The volume of gas under varying conditions of pressure is inversely proportionate to the pressure (Boyle's Law), and when heated it increases in volume according to a special law (Charles' Law). Gases diffuse at a rate inversely proportional to the square root of their densities.

IMPURITIES OF AIR.

The chief sources of impurity of the air are the following :—

(1) Products of respiration.
(2) Products of combustion.

(3) Products of decomposition.
(4) Dust.
(5) Bacteria.

1. *Products of respiration.*—These are chiefly carbonic acid, water and organic matter.

The oxygen of the air is absolutely necessary for all living animals. A man usually respires about 17 times in a minute, and at each respiration an adult gives out 25 cubic inches of air, and thus in an hour will pollute 102,000 cubic inches to the extent of 1 per cent of CO_2, which means an excretion of 0.6 cubic foot of CO_2 per hour. The proportion of gases in inspired and expired air per 100 parts are as follows :—

	Inspired air.	Expired air.
Oxygen	20·96	16·40
Nitrogen	79·00	79·19
Carbonic acid	0·04	4·41

Thus it would be seen that the expired air contains 4 to 5 per cent less of oxygen and 4 per cent more of CO_2.

(*a*) *Carbonic Acid.*—The average air contains ·03 to ·04 CO_2 per 100, or 0.3 to 0.4 per 1000 volumes, and if a man breathes for an hour in a room of 1000 cubic feet, the amount of CO_2 at the end of the hour, if no air is admitted or withdrawn meanwhile, will be $0·6+0·4=1·0$ cubic foot. But this amount of CO_2 is unwholesome, and must be diluted till the total CO_2 comes down to 0.6 per 1000. This is done by allowing 2000 cubic feet of normal air per hour, thus making up a total of $2000+1000=3000$ cubic feet of air per hour.

Weight for weight, children require more oxygen and more carbonic acid than adults, and girls less than boys.

(*b*) *Water Vapour.*—The amount of water given off by the lungs and skin is about 10 and 20 fluid ounces (30 ozs. in India) respectively. The tendency of the air is to reach saturation, and this makes the air of a crowded room so uncomfortable.

(c) *The Organic Matters.*—As given off by the lungs and skin the organic matters differ much in health and disease. They consist of vapours from the lungs and mouth, volatile and fatty acids from the skin and particles of epithelium. A compound of an alkaloidal nature is also found. This can be obtained by bubbling air of an inhabited room through distilled water which is rendered fœtid and offensive. It is, therefore, nitrogenous and oxidisable. It gives an appreciable quantity of albuminoid ammonia when distilled with alkaline permanganate. The organic matters promote the growth of microbes, and milk, meat and other foods when in contact with them rapidly become tainted. Ordinarily expired air contains very few microbes.

2. *Products of Combustion.*—The chief products of combustion are carbon dioxide and carbon monoxide. When fuel is burnt the carbon of wood, coal or charcoal unites with the oxygen of the atmosphere and forms either carbonic acid or carbon monoxide. The former is a comparatively harmless compound and the latter is a narcotic poison.

3. *Products of Decomposition.*—Decomposing animal and vegetable matters give off poisonous gases. Sulphuretted hydrogen is evolved from marshes, in collection of refuse and decaying vegetable matter. When present even in the proportion of 1 in 70,000 it is dangerous to human life.

4. *Dust and Suspended Matters.*—Both organic and inorganic substances are suspended in the atmosphere. Scales of epithelium, fibres of cotton, linen and wool, particles of hair, wood, &c., can be found in inhabited but imperfectly ventilated rooms. A peculiar smell hangs about sick rooms or hospitals, chiefly due to the patients' excretions. Micro-organisms, blood-cells, pus-cells, and particles from expectoration, &c., are often present in the air of such places. Particles of dust arising from filing metals, stones or pearls, spinning taxtile fibres of all kinds, cement, &c., add to the suspended impurities of air.

5. *Micro-organisms.*—Certain benign micro-organisms are found in the normal atmosphere. *Penicillium glaucum* is frequently present, *aspergillus* is not rare, micrococci are very common. The becteria found in the atmosphere are carried

in the form of particles of dust. The pathogenic non-sporing organisms, which cannot live in the dry state, can thrive on dust particles sufficiently large to prevent complete drying.

A number of manufacturing impurities also pollute the air. The chief ones are:—

(*a*) Hydrochloric acid gas from alkali works.

(*b*) Sulphur dioxide and sulphuric acid from copper melting and bleaching works.

(*c*) Hydrogen sulphide from chemical works.

(*d*) Carbon monoxide, carbon dioxide and sulphuretted hydrogen from brick-fields and cement works.

(*e*) Carbon monoxide from iron and copper melting works.

(*f*) Organic matters from glue and gelatin factories.

(*g*) Zinc fumes from brass works.

(*h*) Arsenical fumes from metal works, where arsenic is used as an alloy.

(*i*) Phosphorous fumes from match factories.

(*j*) Carbon disulphide fumes from india-rubber works.

Air in Mines.—This is rich in carbonic acid (2 parts per 1000), and contains in addition carbon monoxide, hydrogen and sulphuretted hydrogen. The deficiency of air in oxygen (200 parts per 1000 of air) is the cause of death in mines following explosions. The gases that are formed in a mine after an explosion are called "after damp," whereas "black damp or choke damp" is formed ordinarily, and is the residual gas left on slow oxidation of carbon and hydrogen of coal by air. It does not explode when mixed with air, and it does not support combustion or life owing to the deficiency of oxygen.

Air of marshes usually contains an excess of carbonic acid and water vapour, and generally marsh gas, sulphuretted hydrogen, hydrogen and ammonia.

Sewer Air.—The air of sewers has long been regarded as dangerous and a likely source of infection in certain diseases, but it is only of late that much attention has been directed to its careful examination. The gaseous products of the decomposition of animal organic matter have been sought for, as also the micro-organisms of infectious diseases, *e.g.*, the bacillus of typhoid fever. As a result of investigations the conclusions arrived at are that the air of sewers plays very little part in the conveyance of typhoid fever; and that the air of sewers, as regards organic matter, carbonic acid and micro-organisms, is in a very much better condition than the air of naturally ventilated school rooms.

IMPURITIES DUE TO COMBUSTION.

Coal contributes largely to the impurities of the atmospheric air. There are three kinds of coal,—anthracite or smokeless coal, bituminous coal and lignite. Bituminous coal is used for the manufacture of illuminating gases and for domestic purposes. It gives off during combustion three times its weight of carbonic acid gas, small quantities of carbonic oxide, sulphurous and sulphuric acids, carbon disulphide, sulphuretted hydrogen and moisture. About 1 per cent is given off in the air as soot and tarry products. One pound of coal requires about 240 to 320 cubic feet of air for complete combustion. The impurities imparted to air during combustion of coke and wood are similar to those of coal with the exception that only wood gives carbon dioxide and monoxide with more water but less sulphur compounds. When these products of combustion pass into the air they are at once diluted and purified by the currents of air and by the diffusion of gases.

By 'one candle power' is meant the light given out by a sperm candle burning 120 grs. per hour. This gives out ·4 cubic feet of carbonic acid and consumes about 1000 cubic feet of fresh air. The chief popular illuminant is coal gas. When purified it contains approximately hydrogen 47 per cent, marsh gas 37 per cent, carbonic oxide 6 per cent, illuminants (acetylene, ethylene) 6 per cent, carbonic acid 1 per cent, nitrogen, sulphurous acid, &c., 5 per cent. The products of combustion of coal gas are nitrogen 67 per cent, water 16 per carbonic acid 1 per cent, carbonic oxide variable, sulphurous acid and ammonia. When burnt, one cubic foot of ordinary coal gas gives off half its own volume of CO_2 and 1·34 cubic feet of water vapour; therefore, the degree of pollution of air can be easily estimated knowing that on an average 4 cubic feet of gas per hour is consumed.

Coal gas unconsumed is poisonous, minute escapes are very dangerous. Of the ingredients of coal gas all except hydrogen, nitrogen and the hydro-carbon vapours are in various degrees poisonous. When burnt, coal gas yields also CO_2 and SO_2, consequently coal gas, burnt or unburnt, is always an impurity in the air of a room. Some forms of coal gas contain large amounts of carbon monoxide and are specially dangerous.

The incandescent electric lamp is the best source of light from the sanitary point of view, as it not being dependant on the oxygen of the air does not vitiate the atmosphere in any way. The next best is the Welsbach incandescant gas burner; it is an ordinary Bunsen burner, over the flame of which a cap (mantle) of asbestos gauze network is suspended. This is rendered non-inflammable by chemical treatment. The flame itself is intensely hot, though not luminous, and light is produced by the mantle being rendered incandescent and so giving a brilliant illumination—whiter and steadier than the ordinary gas flame. This burner gives off less CO_2 than any average oil lamp, and consumes less than half the amount of gas of an ordinary burner. It evolves half as much heat, but produces three times more illuminating power than the best ordinary gas burner.

DISEASES DUE TO IMPURITIES OF AIR.

A. **Effects of Dust and other Solid Impurities.**—Dust consists principally of mineral particles of formed or unformed organic matter of animal or vegetable origin, *e. g.*, epithelia, fibres of wool or cotton, or particles of animal or vegetable tissues. The effects depend on the amount inhaled and on the physical condition of the particles, whether sharp-pointed or rough, &c. They always injure health and the principal affections arising therefrom are catarrh, bronchitis, fibroid pneumonia, asthma and emphysema. The most important symptoms of lung disease produced from inhalation of dust are dyspnœa and expectoration—first mucous and then muco-purulent. Potters' asthma (emphysema) is due to dust.

B. **Effects of Suspended Impurities.**—Workers in rags and wool suffer similarly from dust. Dust from fleeces of wool have caused anthrax. Mill-stone cutters, stone masons, pearl cutters, sandpaper makers, knife grinders, millers. hair dressers, miners, fur-dyers, weavers, &c., all suffer from diseases of the lungs from inhalation of dust and other suspended matters. Cigar-makers inhale dust of tobacco leaves and may suffer from tobacco poisoning. Inhalation of pollen grains produces hay asthma. Brass founders inhale fumes of oxide of zinc, and suffer from diarrhœa, cramp, &c. Match-makers inhale fumes of phosphorus and suffer from necrosis of the lower jaw. Ulceration and finally destruction of the mucous membrane of the nose occurs in those engaged in the manufacture of bichromate of potash. Workers engaged in the preparation of glass-mirrors often suffer from mercurial poisoning, while plumbers may be attacked with colic and palsy. Workers in arsenic, as those who prepare wall papers and artificial flowers, suffer from symptoms of arsenic poisoning. Besides these, infective matters from diseases like typhoid fever, measles, small-pox, &c., are desseminated through the air probably always in the form of dust.

C. Effects of Gases and Volatile Effluvia :—

(*a*) *The effects of gases* on health are disputed. The chief impurities are :—

(1) Hydrochloric acid vapours which cause irritation of lungs and diseases of the eye.

(2) Carbon disulphide vapours causing headache, muscular pain and depression of the nervous system.

(3) Ammonia causing irritation of the conjunctiva.

(4) Carburetted hydrogen causes headache, vomiting convulsion, &c., when inhaled in large quantities.

(5) Carbon monoxide which imparts a cherry red

colour to the blood, and by interfering with the oxygenation may cause death.

(6) Hydrogen sulphide causes diarrhœa, headache, nausea and muscular and nervous depression.

(*b*) *Effects of effluvia* :—

(1) *Effluvia from Brick-fields.*—Bricks are burnt in two ways, in clamps and in kilns. *Clamp burning* is very offensive, for besides forming the odinary products of combustion, certain pyroligneous matters are also formed, which have a very disagreeable smell and are injurious to health. Clamp burning should not, therefore, be permitted near inhabited localities. In clamps bricks are arranged in quadrangular piles alternating with breeze or combustible materials, and burning is carried out by means of coal fires and chips. Sometimes dust-bin refuse is used to burn the bricks ; in such cases the partially burnt organic vapours are highly disagreable. In *kiln burning* bricks are burnt with the aid of coal only, and if the kilns are provided with flues the liability to nuisance is much less, as the products of combustion are more perfectly consumed.

(2) *Effluvia from Offensive Trades.*—The chief sources of nuisance are from stables, cowsheds, tanneries, fat and tallow factories, gut scraping, bone boiling, paper making, carbolic acid manufacture, &c. The majority of these trades gives rise to disagreeable and offensive vapours which affect health.

(3) *Effects of Gas from Sewers and House Drains.*—The air in the main sewer is purer than that of the house drains. Among the effects may be mentioned diarrhœa, gastro-intestinal affections, sore-throat, diphtheria, anæmia and constant ill-health. Diseases like cholera, enteric fever, erysipelas, measles, scarlet fever, &c., are aggravated by sewer gas. Children are affected more than adults. A severe form of tonsillitis is often found in the occupants of a badly drained house. This is commonly known as "sewer air throat". Persons working in well ventilated sewers do not usually suffer from any illness, but if ventilation is wanting syncope may occur.

(4) *Effluvia from Decomposing Organic Matter.*—Gases from decomposing carcasses cause outbreaks of

diarrhœa and dysentery. Gases from manure and similar manufacturies cause nervous depression, gastro-intestinal irritation and occasionally ophthalmia.

D. **Effects of Air Vitiated by Respiration.**—When carbonic acid in a room exceeds 6 volumes per 1000, the atmosphere becomes perceptibly close and stuffy to a person entering from outside. This sense of discomfort is due to the excess of CO_2, deficiency of oxygen and to increased heat and moisture. The effect of expired air has a deteriorating influence on health, as it produces heaviness, headache and nausea.

Regular breathing of vitiated atmosphere is very injurious to health. Persons soon become anæmic and suffer from anorexia, and after sometime become weak and depressed in spirits. The resisting power becomes greatly lowered and phthisis may occur.

Examination of Air.

Collection of the Sample.—For examination purposes, air is best collected in large wide-mouthed glass jars of about 3 to 4 litres capacity, thoroughly cleaned and dried. The sample should be taken at the time when the atmosphere is at its highest degree of vitiation, as for example, in case of school rooms when all the students have been in the class for some time. There are two methods of taking the sample :

(1) Take the jar filled with distilled water into the room, and empty it by turning it upside down. Dry it in the room and put the stopper lightly or cover it up with an india-rubber cap, so that no outside air can get an entrance.

(2) Air may be blown in by bellows having a long nozzle, so that it would reach the bottom of the jar, and displace air from the very bottom.

The vessels should always bear a label on which the cubical capacity of the jar, the barometric pressure, and the temperature at the time of the collection of the sample should be noted.

1. **Examination by the Senses.**—One with an acute sense of smell can readily detect the presence of carbon disul-

phide, sulphuretted hydrogen, coal gas, organic matter, &c. De Chaumont was the first to point out that the peculiar fœtid smell perceived on entering an inhabited room from the outside was the result of the influence of atmospheric humidity on the organic matter. The impression on coming from the open air into an inhabited room should at once be recorded, as the sense of smell gets dulled very soon. The smell also depends on the cleanliness or otherwise of the room and its occupants.

2. **Chemical Examination.**—The ill effects are due more to the presence of CO_2 and organic matter than to the deficiency of oxygen. Hence the determination of CO_2 in air is of great value—being the product of combustion and respiration it gives an index as to the degree of pollution of the air. The popular method of estimating the amount of CO_2 is that of Pettenkofer, and depends on the fact that an alkaline medium like lime water or baryta water absorbs CO_2, their alkalinity being thus diminished. Therefore the difference in the degree of alkalinity before and after the experiment gives an index of the amount of CO_2.

Technique.—Add 50 Cc. of clear and fresh baryta water to the sample of air and replace the stopper. Allow it to stand for sometime with occasional shaking to allow the CO_2 to mix with the baryta water to form carbonate of barium. The alkalinity of baryta is determined by a standard solution of oxalic acid, 1Cc. of which is equivalent to 5Cc. of CO_2. Phenolphthalien is also used as an indicator, the colour disappearing on neutralisation.

The following illustration is taken from Pakes' Laboratory Text Book of Hygiene, p. 292 :—

The jar is found to contain 3950 Cc.

As 50 Cc. baryta water were run into the jar, the air experimented on$=3950-50=3900$ Cc.

On titrating 25 Cc. of the original baryta water, 22·50 Cc. standard acid solution were required to neutralise it.

The baryta water in the jar required 19·35 Cc.

$22{\cdot}50-19{\cdot}35=3{\cdot}15$ Cc.$=$difference of acid used. But 1 Cc. of acid$=0{\cdot}5$ Cc. CO_2 at 0°C. and 760 mm. of mercury.

Therefore CO_2 taken up by 25 Cc. of baryta$=\frac{3\cdot15}{2}=1\cdot575$ Cc.

As 50 Cc. were used the CO_2 absorbed by the baryta $=3\cdot15$ Cc.

This was present in 3,900 Cc. of air. Therefore the CO_2 $=0\cdot80$ per cent.

Correction may be required for variations from the normal pressure of 760 mm. and normal temperature of 0°C., in accordance with ordinary rules.

Haldane has described a simple and convenient method for estimating CO_2. For particulars the reader is referred to the *Journal of Health*, No. 1,1901.

Organic impurities may be estimated by aspirating a definite amount of air through a freshly prepared dilute solution of potassium permanganate of known strength. The result is determined by calculating the number of cubic feet of air required to decolorise ·001 grm. of potassium permanganate in solution.

3. **Microscopical Examination of Air.**—Aspirate slowly air through a series of bottles each holding about 100 Cc. of distilled water, and allow the suspended matter to settle, drain off the supernatant fluid and examine the residue under the microscope.

4. **Bacteriological Examination of Air.**—Various methods have been suggested, but Hesse's apparatus gives most accurate results. This consists of a glass cylinder about 18 inches long and 2 inches in diameter through which the air is drawn. Inside the cylinder, which has been previously sterilised, 50 Cc. of liquid gelatin is allowed to solidify, over which the germs are deposited during the passage of the air. The ends of the tube are then plugged with sterile cotton wool and is placed in the incubator for twenty four hours or more, after which the colonies can be counted or differentiated by their appearance or other tests.

CHAPTER III.

VENTILATION AND COOLING.

The term "ventilation" has a very wide significance but it is generally restricted to the means of removal or dilution of the foul gases and impure suspended matters which have accumulated in the atmosphere of buildings inhabited by men and other animals. This is sometimes called *internal ventilation.* But in the case of the general air space of towns advantage is taken of the natural means of purification of air. This is done by making the streets broad, building houses moderately high, and not very close to one another, so as not to impede free circulation of air. This *external ventilation* is of primary importancc, for upon the purity or otherwise of outside air depends the possibility of good internal ventilation. Efficient external ventilation may also be ensured by preventing other impurities from entering the air, by watering the streets to lay the dust, by careful inspection of all drains and sewers, by the transport of all offensive trades and occupations to special quarters, by speedy removal of street and other refuse and by keeping plenty of open spaces and parks.

Amount of Air Required for Ventilation.

This depends upon the amount of impurities present in the air requiring dilution and dispersion. Ventilation aids only in the removal of the products of respiration and combustion. Whatever might be the impurities, carbon dioxide is regarded as the chief index of air vitiation.

1. **Amount of Air required for the Healthy.**—The question naturally arises what would be the standard of purity of air in a dwelling house? A room should ventilate itself thoroughly when all the doors and windows are closed, so that a person coming from in fresh air should not

perceive any smell or stuffiness. It has been found by experience that when the amount of CO_2 in a room exceeds ·6 volumes per 1000, the air gives a distinct feeling of tightness to a person entering from outside, and it is usual to adopt this as the standard of purity. The amount present in pure air is ·4. The object of ventilation is to prevent the CO_2 from exceeding ·6 per 1000. De Chaumont holds that vitiation to the extent of ·2 per 1000 and not greater may be allowed with impunity. Hence the *permissible limit* of respiratory impurity is 0·2 per 1000 or 0·2 cubic foot of CO_2 per 1000 cubic feet of air. The amount of CO_2 varies with the weight and activity of the person. For a mixed community ·6 cubic foot of CO_2 per hour may be taken as the general average, and for adult males ·7.

By dividing the amount of CO_2 exhaled in an hour by the permissible limit of respiratory impurity, De Chaumont estimated the number of cubic feet of air per hour required for each person. This is the standard now accepted on all sides, and is expressed as under:

$$\frac{e}{p}=d,$$

where e=CO_2 exhaled in an hour per head, *i.e.*, ·6 cubic foot.
p=limit of respiratory impurity per cubic foot.
d=the delivery or amount of fresh air available in cubic feet per hour.

Therefore $\frac{\cdot 6}{\cdot 0002}=3000$, the number of cubic feet of air necessary for every individual of average weight per hour. This formula may be used conversely to find out from the condition of air the amount of fresh air that has been supplied and utilized. But for this purpose we substitute p_1 for p (the limit of respiratory unit), the observed ratio: thus, $\frac{e}{p_1}=d$.

Suppose total CO_2 in a room is 1.1 per 1000, or 0.0011 per cubic foot it is 0.0004 in the atmosphere; therefore p_1 is $0.0011-0{\cdot}0004$ or 0·0007: thus $\frac{e}{p_1}=d$ or $\frac{0{\cdot}6}{0{\cdot}0007}=857$ cubic feet of air supplied.

By transposing the last formula we can calculate the probable state of the air of a room into which a known quantity of air has been or is being admitted. Thus $\frac{e}{d} = p_1$.

If five persons occupy a room with a capacity of 6000 cubic feet for 6 hours, and allowing 8000 cubic feet of air per hour, what would be the percentage of CO_2 at the end of the hour ?

Each person gives off 0·6 cubic foot of CO_2 per hour. Therefore $0·6 \times 5 \times 6 = 18$ cubic feet of CO_2 for five persons in six hours.

Thus $\frac{e}{d} = p_1$ becomes $\frac{18}{54000} = p_1$, or 0·00033 per cubic foot or 0·033 per cent. Men doing heavy work generally give out about ·2 cubic feet of CO_2 hourly, consequently a greater amount of fresh air is necessary.

The average hourly exhalation of carbon dioxide for a child is ·4 cubic foot and for an adult male 0·72.

An	adult	male	requires about	3600	cubic feet	per hour
,,	,,	female	,,	3000	,,	,,
A		child	,,	2000	,,	,,

In a mixed community 3000 cubic feet are required.

2. **Amount of Air required for the Sick.**—For sick persons in hospitals the amount of fresh air should exceed that required by the healthy at least by one fourth. For instance if 3000 cubic feet be the average in health, 3750 cubic feet will be required in sickness per hour. In serious cases like typhoid fever or small pox, twice as much or even more is required.

3. **Amount of Air required for Combustion.**—An ordinary flat-flame gas burner which generates about $2\frac{1}{2}$ cubic feet of CO_2 will consume 5 cubic feet of gas per hour, 1000 cubic feet of air are needed for every cubic feet of CO_2 per hour. Therefore about 2250 cubic feet of fresh air must be supplied per hour for each gas burner in a room.

The following table modified from Notter and Firth shows the relative amount of oxygen removed from the air, carbon dioxide given off, and quantity of carbon consumed, per hour by various forms of artificial light :—

	Quantity consumed.	Oxygen removed.	CO_2 produced.	Vitiation equal to adults.
Tallow candle ...	2200 grs.	10·7 C. ft.	7 3 C. ft.	12·0
Kerosine oil lamp	909 ,,	5·9 ,,	4·1 ,,	7·0
Coal gas ...	5·5 C. ft.	6·5 ,,	2·8 ,,	5·0
Coal gas (incandescent) ...	3·5 ,,	4·1 ,,	1·8 ,,	3·0
Electric light (incandescent).	0·3 lb. coal	0·0 ,,	0·0 ,,	0·0

It will be seen from the above table that the electric incandescent lamp is the best light from hygienic point of view, all other lights being more or less dependent upon the absorption of oxygen from the air vitiate the atmosphere by certain products which affect the health to a greater or less degree.

4. **Amount of Fresh Air required for Animals.**—Animals require fresh air as much as men do. A horse or a cow ought to have about 10,000 to 20,000 cubic feet of air per hour, in the ratio of 20 to 25 cubic feet per hour for every pound of body weight. Wild animals need more air than the domestic ones, and the smaller animals require more air in proportion to their weight owing to their more rapid tissue change.

METHODS BY WHICH THE REQUIRED AMOUNT OF FRESH AIR CAN BE SUPPLIED.

Practical ventilation is an engineering problem, but the conditions of ventilation can never be the same, owing to the fact that the rooms and houses needing ventilation vary greatly. No single system therefore is applicable to all. But the fundamental principles are more or less the same.

The physical theory of ventilation may be stated in two propositions* :--

(*a*) Given a 'head of air,' a continuous flow can be maintained through a room, the amount of air entering and leaving being equal,

(*b*) a 'head of air' is produced by difference of pressure between the air within and the air without the room.

Now the question is how to produce such a head of air or more appropriately how to provide each individual with approximately the quantiy of air mentioned before ?

One of the conditions of efficient ventilation in this country is that the means adopted must not have the effect of raising the temperature of the space to be ventilated. In cold countries it is often necessary to warm the air to be introduced, but in India the temperature has to be lowered.

SYSTEMS OF VENTILATION.

Ventilation may be classified into—

A. Vacuum System.
B. Plenum System.

The common division into *natural* and *artifiicial* or *mechanical systems* is quite inappropriate, since the so called natural systems are artificial to a high degree, and the mechanical systems involve practically the same principles.

A. Vacuum or Extraction System :

1. **Open Fire with Flue.**—The principle underlying this system is that heat expands the volume of air in the chimney, reduces the density, and thus causes an upward flow which in turn sets up a current in the room-air. Hence the chimney acts as an outlet and the inlets are the openings as

---

* Green's Encyclopædia of Medicine and Surgery.

crevices, doors, windows, &c. The efficiency of ventilation depends upon the difference between the temperature maintained in the chimney and the temperature of the air outside. The discharge of air by an ordinary open fire and chimney varies greatly, and it depends on the rate of combustion, the height, section and form of the chimney, and the ease with which the air enters the room. Even when no fire is burning the chimney plays an important part in ventilation: the air inside the room being warmer than the outside air, it is only necessary that an up-current should be started in order that the chimney should maintain it. Mines are usually ventilated in this way by lighting a fire at the bottom of a shaft. The ventilation is maintained by an intake shaft through which air is drawn down, and travels through all the workings and galleries of the mine before it escapes through upcast or return shaft. The main point to remember in this system is that the fire should be put at the bottom of the upcast shaft or half a shaft if there be only one. By this method about 1000 to 2000 cubic feet of air is supplied per head per hour, but in mines where fire damp is evolved as much as 6000 cubic feet of air per hour per man is given.

Many public halls, hospitals and other large buildings are ventilated by this method of extraction system.

2. **Inlets and Outlets.**—The openings through which ventilation is carried out are known as inlets and outlets. Inlets are intended for the entrance of pure air and the outlets for the escape of vitiated air.

In warm climates the doors and windows supply all necessary ventilation, and in some instances pervious walls, as of bamboo, allow free perflation without any harm whatever. In colder climates the doors and windows have to be closed and special arrangements must be made for inlets. The chimney very well serves the purpose of an outlet but if insufficient other outlets must be provided.

(*a*) *Inlets.*—The chief point with regard to the inlet openings is that they should be selected in such positions that the air supplied be pure and not polluted before admission. In India where ventilation is carried out through doors and windows, these should as far as possible be on opposite sides of the room. Where special inlets are provided they should be near the floor, and from 24 to 48 square inch in area for each person. When the supply of air is cold, as in the hill stations, the current of air to which the body is exposed will be felt as a draught and might be intolerable. But the current may be allowed to enter without causing discomfort, provided its direction keeps it from striking directly on the persons of the inmates. To secure this it should enter vertically through openings high enough to carry the stream into the upper atmosphere of the room where it will mix with warm air before its presence can be felt.

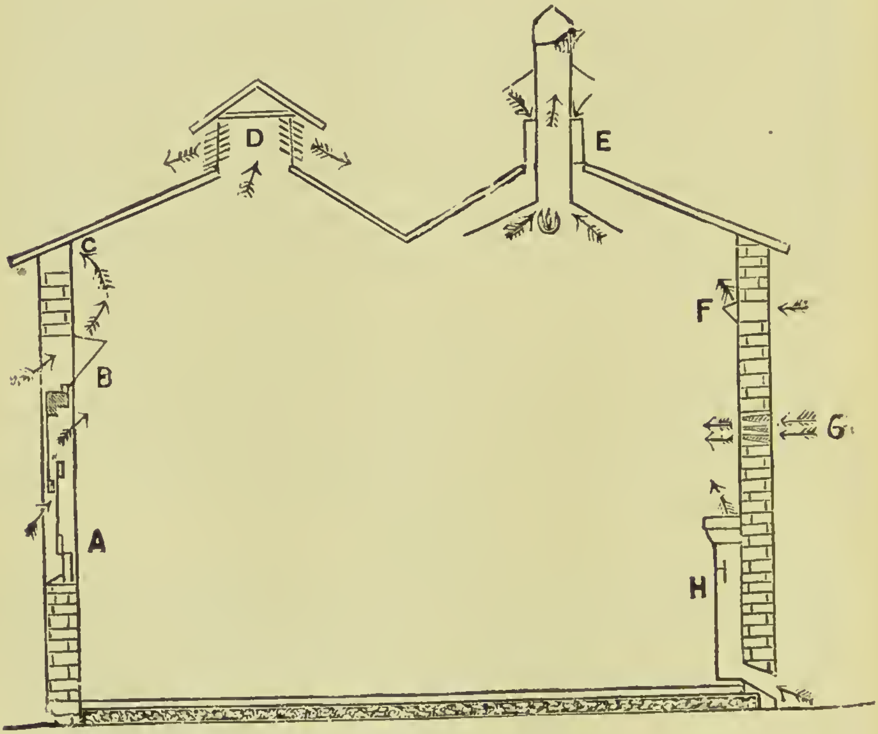

Fig 6.

(After Parkes and Kenwood)

Sketch of various provisions for ventilation. A, Sash window. B. Hopper Sash-light falling inwards. C, Ridge ventilation. D, Louvred outlets. E, McKinnell's ventilator. F, Sheringham's valve. G, Ellison's conical bricks. H, Tobin's Tube.

The common forms of inlets are :—

(1) *Double Sash Window* with an air space between. Swinging windows are often employed as inlets specially in hospitals and schools.

(2) *Louvres or ventilators* made on the principle of venetian blinds. These can be opened or closed at will by a mechanical arrangement.

(3) A hinge at the upper part of the window so that it can fall forward and act as a Sheringham's valve.

(4) *Bricks perforated with conical holes* with the narrow end outside. The air passing through the narrow to the broad end is so distributed that it is not felt as a draught.

(5) *Tobin's Tube.*—It is a short vertical shaft of metal plate or wood which leads up the wall from the floor level to a height of 5 or 6 feet. The lower end opens into the outer air through an air brick or an opening made in the wall ; the current of fresh air rises in a smooth stream through the upper opening and it does not seem to change its direction until it has gone far above the opening.

(6) *Sheringham's Valve.*—This is a flap door placed near the ceiling, and when opened forms a wedge-shaped projection into the room, and admits air through the open top in an upward direction.

(7) *McKinnell's Ventilator* consists of an inner and outer tube, one encircling the other ; the inner forming the outlet tube, and projecting beyond the outer both outwards and inwards.

(*b*) *Outlets.*—As a general principle the outlet should if possible be single. By this friction will be less, efficiency better regulated and there will be less risk of contrary action between them. Respired air has a tendency to go upwards and outlet openings are best provided at the upper part of the room. Rooms with sloping roofs can have outlets in the form of *ridge-openings* along the entire top. If intake of air is provided for, the outlet will look after itself.

The regulation of the ventilation openings are of some value. In colder climates it is better for the windows to open at the top with a slope from below upwards and inwards, so that the cold air may be directed upwards and then sink by its own weight. In India the windows almost always open either outwards or inwards and consequently the regulation of the direct force of the wind is not very easy. By keeping the venetians partly closed, and the inner glass windows open, excess of light and wind may be prevented from entering the room.

B. Plenum or Propulsion System:

In this system the air is forced by mechanical forces like fans, stoves, steam heated coils, steam jets or other appliances. This mechanical system of plenum ventilation is frequently adopted in schools, hospitals, &c., where the cubic space per head is necessarily small.

1. **Propulsion by Steam Jet.**—The force of the steam jet forms the motive power. Tubes passing from adjacent rooms converge into the chimney below the steam jet and the upward current extracts air from them. This plan is very suitable in factories where there is a spare supply of steam.

2. **Propulsion by means of Pumps.**—This is used in some collieries.

3. **Extraction and Propulsion by Fans and Punkhas.**—These are extensively used in tunnels, public halls, offices, schools, &c. Fans are usually worked by electricity, steam, or gas, and punkhas by manual labour or steam. Propulsion by fans is the best and most certain method of efficient ventilation.

It should be noted that where the air space is large there is less need of frequently changing the air. For a single man in a room having an area of 100 cubic feet the air should be changed thirty times per hour if 3000 cubic feet of air be given, whereas if the area of the room be 1000 cubic feet the air requires to be changed only three times per hour, for equal ventilation. By suitable arrangements about half a dozen changes of the air of a room can be made without any draught being felt.

The authorized amount of space alloted per head are as follows :—

Soldier	600 Cft.	
Dormitories of poor houses	300 ,,	(healthy person)
,, ,, ,,	850 to 1200 Cft.	(sick person)
Poor-law schools	360 Cft.	
Registered lodging houses	300 ,,	(above 10)
,, ,, ,,	150 Cft.	(under 10)

The allowable minimum floor space should not be less than one-twelfth of the cubic space.

Animals require fresh air as much as men do, and it has been estimated that for every pound of animal weight, 2 cubic feet of air space must be supplied, the floor space being not less than one-twelfth of the cubic capacity.

PURIFICATION OF AIR.

Purification of air may be brought about by both natural and artificial methods. The natural methods are very important and are as follows :—

1. **Rain.**—This carries dissolved or suspended matters to earth as evidenced by an increase in the amount of ammonia, &c.

2. **Plants.**—The green parts containing chlorophyll take in CO_2 from air and assimilate carbon and give off oxygen to the atmosphere.

3. A few constituents that enter into the composition of the atmosphere help also to purify the air. These are *oxygen* and *ozone*. The ammonia and organic impurities are washed down with the rains as nitrites and nitrates.

4. **Ventilation**, *i.e.*, the interchange of pure and impure air. Besides the methods already described by which ventilation is carried on, there are three other *forces concerned in ventilation*, *viz.*, diffusion, winds, differences of temperature of masses of air.

(*a*) *Diffusion.*—Gases diffuse inversely as the square root of their densities. It has been shown by Pettenkofer and Roscoe that diffusion takes place in a room which is not air-tight, the air moving in and out in every possible direction, either through bricks, chinks and crevices of doors and windows, &c. But under ordinary circumstances the diffusion, if there be any, is very small and organic substances, which are not gaseous, but molecular, are not at all influenced by it. Therefore diffusion as a ventilating agent is inadequate.

(*b*) *Winds.*—Wind is a very powerful ventilating agent. Ventilation is carried out partly by what is called perflation, and partly by aspiration. Certain objections may be raised against winds as ventilating agents. They are:—

(i) The air may be very stagnant, and consequently ventilation becomes most imperfect.

(ii) The difficulty of regulating the velocity of the current, which by blowing very heavily against an exit shaft, might impede ventilation by obstructing the exit of air.

The perflating power of the wind has in some systems of ventilation been used as a motive power, specially in the ventilation of holds and cabins of ships at sea. The wind is conducted below by means of tubes with cowls so arranged as to face the wind, the vitiated or used air escaping through a different opening. The aspirating power of the wind and the production of a head of air, when wind blows over the top of a tube, can be secured by covering air shafts with cowls. which while assisting up currents prevent down currents. No cowl, however, is effective save that it prevents foreign bodies, birds, rain, &c., from entering into the shaft. Some are rotatory and the disadvantage is that these are active in high wind when they are not needed and stationary and obstructive in a calm when they are wanted. In Indian towns where narrow lanes are abutted by high buildings ventilation in the lower rooms becomes necessarily imperfect. Movements of air in such rooms can be best ensured by large metal pipes inserted through the roofs with funnel-shaped mouths turned towards the wind.

(c) *Effects of differences of Temperature of Masses of Air.*—Unequal temperature causes unequal weights in masses of air. If the air of a room be heated by fire or by products of respiration of men and animals or be made more or less moist, it tends to expand, and rises up or escapes through other openings. The outer colder air rushes in through every opening until the temperature of both outside and inside air becomes equal. But the incoming fresh air in its turn becomes heated and so a constant current is maintained. In India when the air is very stagnant and the difference of temperature between the external and internal air is almost nil, ventilation is more imperfect and heat is correspondingly increased. This is very common in large buildings like town halls which become suddenly crowded.

EXAMINATION OF VENTILATION OF A ROOM.

The amount of ventilation in a room can be calculated by the following means :—

1. Determine the amount of cubic space and floor space alloted to each person and the rate of movement of air.

2. Examine the air by chemical, bacteriological and mechanical methods, and by the senses. Estimate the amount of suspended matters, organic impurities, &c.

3. Note the number, size, and position of the inlets and outlets, and the amount of air entering and leaving the room, and particularly whether the distribution is thorough.

4. A thorough examination of the building and its surroundings must be made with a view to the discovery of rubbish, foul drains, latrines, &c.

Determination of the Amount of Cubic Space.—This is done by multiplying the length, breadth and height where the room is regular in shape. Where the rooms are irregular in form with angles, projections, &c., certain rules for measurements of the areas of circles, segments, triangles, &c., must be followed. It is seldom necessary to make deductions for furniture like chairs, tables, &c., that occupy only a small space. But deductions must be made for bodies of persons living in the room and for solid furniture like cup-boards, bedding, &c. which occupy a certain amount of space. Recesses containing air should also be measured and added to the amount of cubic space. The cubic contents of a room can be determined by any one of the following rules:—

Circumference of a circle = diameter (D) × 3.1416.

Area of a circle = $D^2 \times \cdot 7854$.

Area of an ellipse = product of the two diameters × ·7854.

Circumference of an ellipse = half the sum of two diameters × 3·1416.

Area of a square = square of one of the sides.

Area of a rectangle = the product of two adjacent sides.

Area of a triangle = base × $\frac{1}{2}$height, or height × $\frac{1}{2}$ base.

Area of a parallelogram = Divide into two triangles by a diagonal, and take the sum of the areas of the two triangles.

Cubic capacity of a solid rectangle or a cube found by multiplying three dimensions together.

Cubic capacity of a cylinder = Area of base × height.

Cubic capacity of a cone or pyramid = Area of base × $\frac{1}{3}$ height.

Cubic capacity of a dome = Area of base × $\frac{2}{3}$ height.

Cubic capacity of a sphere = $D^3 \times \cdot 5236$.

The number of cubic feet of space per head is determined by dividing the total number of cubic feet (after necessary additions and deductions) by the number of persons occupying the room. The floor space per head is determined by dividing the total area of the floor by the number of persons.

The rate of movement of the air in a room is determined by first ascertaining the direction of the air. It is necessary at the outset to enumerate the various openings of the room, acting as inlets and outlets, which will furnish a key in ascertaining the direction of the movement of the air. Inlets are distinguished from outlets by noting the direction of the smoke disengaged from smouldering brown paper and cotton velvet when held close to the openings.

The rate of movement of air can be ascertained by means of an airmeter or anemometer.

HEATING AND COOLING.

We have now to consider the problems pertaining to the heating and cooling of houses. This subject is intimately related to ventilation as difference of temperature is one of its causes. Heating of dwelling houses in India is restricted to certain hill stations, and even there only in winter. The opposite process of cooling the houses and atmosphere is more a necessity in India than that of heating. The means of producing heat are many, though less needed, while the methods of keeping the rooms and air cool are not only very limited but unsatisfactory in the extreme. A short description, however, of both these methods is given below :—

I. **Distribution of Heat.**—For the purposes of heating houses and ventilation heat is commonly produced by the combustion of fuel, which is distributed by—

1. Conduction or direct contact.
2. Radiation.
3. Convection.

1. **Conduction.**—Solids are good conductors of heat, while liquids and gases are bad ones. Good conductors give off heat rapidly to the surrounding air and other articles in contact with them.

2. **Radiation.**—By this is meant the giving off of heat from hot bodies to colder ones through the air. During radiation heat is transmitted in straight lines on all sides with equal intensity. The intensity of heat is in inverse ratio as the square of the distance. Thus if the heat at one foot distance from a fire be one, then at four feet it will be sixteen times less.

3. **Convection.**—By this process heat is transmitted through gases and liquids, and depends upon a peculiar tendency of these bodies to expand with heat and thus become lighter and rise upwards, their place being taken up by colder and heavier portions, which in their turn become warm, expand and ascend, thus setting up a process of circulation.

The common methods of heating dwellings are :—

(*a*) Open fire places and Grates.

(*b*) Closed fires or Stoves.

(*c*) Pipes charged with hot air, hot water or steam.

(*a*) *Open Fire Places.*—This method is most extensively used in England, on account of the cheerfulness of the room and efficient ventilation which they ensure. Notter and Firth, following Teale, recommend the under-mentioned points for the preparation of fireplaces :—

(1) Use less iron but more firebrick specially for the back and sides.

(2) The back of the fireplace should lean or hang over the fire, and the throat of the chimney should be contracted.

(3) The bottom should be deep from before back.

(4) All slits in the bottom and the bars in front should be narrow.

(5) The space beneath the fire should have a close fitting iron shield or " economiser " in front.

(*b*) *Closed Fires or Stoves.*—In this method heat is obtained by burning fuel in a grate enclosed by a good conducting or absorbing material on all sides except below the bars. The air coming in contact with this heated surface becomes warmed and thereby heat is disseminated. These stoves are usually made of cast iron, bricks or tiles. Coal, coke, paraffin, &c., are burnt in these stoves.

The objections to the above method are :—

(i) The coal makes the air hot and dry.

(ii) A peculiar close smell due to the decomposition of organic matter is present.

(iii) Products of combustion, *e.g.*, carbon monoxide escapes through the stove.

Gas Stoves.—These are good for cooking and in cases where heat is required quickly and for a short time only.

Gas stoves should always have a flue otherwise the products of combustion left in the room would affect the health of the occupants.

Oil Stoves are very useful especially for people in the mofussil. These are also convenient for small rooms. Mineral oils used should be of good quality.

(*c*) *Heating by hot air, hot water and steam.*

(1) *Heating by Hot Air.*—This is only resorted to when it is not desired to keep fire or stove in the room—an arrangement specially suited for large public buildings. The air is warmed in some part of the building and then conducted through pipes into different rooms, &c.

(2) *Heating by Hot Water and Steam.*—Water and steam are both utilised for the purpose of heating houses. Steam pipes are used for heating factories, work shops, &c., where extra steam is easily available. There are two methods by which hot water pipes are conducted : (i) the so-called low pressure system, (ii) Perkin's high pressure principle.

(i) In the low pressure system the pipes are about four inches in diameter. The principle underlying this system is that a circulation of water is kept up by a system of pipes distributed round the house, having connection with the main boiler to form a complete cycle. The hot water leaves the boiler from the upper part, while after circulation the water re-enters the boiler at its lower part. In passing through the pipes the hot water gives off its heat to the air in contact with them to the various parts of the buildings. A feed-pipe enters the return pipe near the boiler, while the escape of air is provided at the top of the system.

(ii) In Perkin's high pressure system the water is carried through wrought-iron pipes, strong enough to stand the heat and pressure ; these pipes are arranged in the form of a complete circuit, part of which in the form of a coil passes through the furnace. No boiler is therefore used in this system.

II. **Artificial Cooling of Air.**—The first point to be attended to is to try and prevent direct radiation of the sun from entering the room. This is generally done by keeping the doors and windows closed during the day time. By this method the air inside the house is rendered much cooler than the air outside, and a circulation is thereby established. The outside air can be made cooler by passing it by means of Thermantidotes or fan-wheels through wet *khus-khus* mats or tatties which will have the additional effect of acting as filters by removing all suspended impurities of air. Fans and punkhas though used as propellers also help to keep the room cool. By condensation and rarefaction of air certain changes in the temperature may be produced. By suitable arrangements of expansion cylinders, it is possible to have a supply of cold air, the temperature of which is much below that of the surrounding bodies. This method of cooling is now utilised in refrigerating chambers in ships carrying meat.

CHAPTER IV.

OFFENSIVE TRADES.

Certain trades have to be supervised by sanitary officials, partly on account of their being a source of nuisance because of the smell or effluvia which they give off which might act injuriously on the health of the people, and partly also on account of the materials or processes employed which have an influence prejudical either upon the health of the workmen, or upon the surrounding populations. In India much importance is not attached to the supervision of offensive trades. With the increase of different industries it is necessary that they should be under the control of some sanitary law. All such businesses should be carried on at a distance from populous localities.

Ballard has classified offensive trades as follows :—

1. Keeping of animals.
2. Slaughtering of animals.
3. Other branches of industry in which animal matter or substances of animal origin are chiefly dealt with.
4. Branches of industry in which vegetable matters are principally dealt with.
5. Branches of industry in which mineral substances are chiefly dealt with.
6. Branches of industry in which matters of mixed origin are dealt with.

1. **Keeping of Animals.**—Pigs, horses or cows often create a nuisance arising chiefly from storing of grains and other food stuffs in a wet state, accumulation of dung and soakage of urine, &c., into the ground. Cowsheds, stables, &c., should therefore be properly constructed (which see). The

discharges should be received into covered vessels. The sheds should be washed and cleaned daily. Effluvia also arise from improper storage of sour and foul smelling food with which the pigs are generally fed. These should be stored in impervious vessels with proper covers.

Keeping of poultry is also a source of nuisance and should be discouraged in small houses and cellars.

2. **Slaughtering of Animals.**—Slaughter houses may be either private or public. Private slaughter houses should as a rule be discouraged as they facilitate the slaughtering of diseased animals. Nuisances arise from the dirty way in which the animals are usually kept. Storage of decomposed carcases and garbage also adds to the filthiness.

Slaughter House.—In the construction of a slaughter house the following points should be noted:—

(1) It should not be within a hundred feet of any dwelling house and should be open to the air at least on two sides.

(2) It should always be above the ground level.

(3) There should be no room or loft over the slaughter house.

(4) There should be an abundant supply of water and the cistern placed a few feet above the floor.

(5) The floor should be made of some impermeable material with proper slope and channel to a gully.

(6) The walls in the interior should be covered with hard, smooth and impervious material to a sufficient height.

(7) There should be no water closet or privy within the slaughter house.

All refuse, blood, manure and garbage are to be placed in vessels of non-absorbent materials with close-fitting covers immediately after slaughtering. All skins, fats, &c., are to be removed from the slaughter house within twenty four hours.

3. **Blood-boiling or blood-drying.**—Blood collected from slaughter housesi s utilised for (*a*) making blood albumin,

(*b*) manufacturing turkey red pigment, (*c*) preparing blood manure, and (*d*) refining sugar.

Sanitary precautions.—The floor, vessels, &c., should be kept scrupulously clean, and blood when not in use should be properly stored to prevent the escape of offensive gases. There should be proper arrangements for drainage and condensation of escaping gases which are usually offensive.

4. **Bone-boiling.**—For the preparations of gelatin, glue and fat the bones are boiled along with hoofs, &c. Handles of knives, forks, &c., are prepared from boiled bones. The bones may also be utilized for the manufacture of superphosphate manure. The vapours are usually very offensive and give off musty ammoniacal odour. The sanitary precautions to be observed are the construction of suitable buildings, using steam jacketed cylinders for condensing vapours, making proper arrangements for drainage and storage, and conveyance of the materials.

5. **Gut-scraping.**—This is generally done for the purpose of making sausage skin, catgut, &c. The small intestines of swine and sheep are first washed and cleaned and softened by soaking in salt solution for a few days, and then scraped on a bench by a piece of wedge-shaped wood until a little of the muscular coat and the peritoneal covering is only left. These are finally washed and dried.

Nuisance is prevented by (*a*) making the floors and walls of non-absorbent materials, (*b*) good drainage, (*c*) providing marble-topped tables, (*d*) prompt removal of waste materials, (*e*) careful washing and cleaning of the premises, and (*f*) preventing improper and prolonged storage.

6. **Fat and Tallow Melting (soap boiling).**—Fat is usually obtained from butchers or marine store dealers in a more or less decomposed condition. It is utilized in the manufacture of candles, soaps, leather-dressings and preparations for lubricating machinery. The fat "is melted either in pans (*a*) heated by an open fire, or (*b*) in pans which are steam-jacketed, or (*c*) by free steam and sulphuric acid." *Tallow* is beef or mutton fat or a mixture of both prepared and melted by one or other of the above means.

Nuisance may arise from—(*a*) improper conveyance or storage of material, (*b*) storage of residue, (*c*) general filthiness and unsuitability of the premises, and (*d*) vapours escaping during the process of melting or boiling of the fat.

7. **Fellmongering and Leather-dressing.**—A fellmonger prepares either fresh or old skins for the leather dresser and a leather dresser and tanner converts the skins into various kinds of leather. The fresh skins are first bitten to get rid of the dirts and then soaked in water and washed. The hair is removed by the addition of lime. The old or foreign skins are first softened by soaking in water until decomposition sets in when the hair or wool becomes loose and is removed easily. This is known as the "tanning process." The skins devoid of hair are known as "pelts" which are thrown into a pit containing milk of lime. They are then taken to the leather dresser or tanner. By process of 'tanning' the putrescible hides are converted into non-putrescible and more or less flexible materials commonly known as "leather." The leather is rendered soft and water-proof by treating with fatty and other materials.

Nuisances arise from (*a*) filthiness or unsuitability of the building, (*b*) improper conveyance or storage of skins, (*c*) unsatisfactory way of disposal of the dirt, flesh and waste water.

All offensive materials should be conveyed in non-absorbent, covered receptacles and kept in special closed rooms ventilated by means of air shafts. General precautions are the same as indicated for other trades before.

8. **Paper-making.**—Paper is prepared from such substances as cotton, linen, rag, waste paper, straw, bamboo, esparto grass, &c. The rags are first dusted and then cut into small pieces, washed and bleached. Esparto grass is reduced to pulp by first boiling with caustic alkali. Nuisance is caused chiefly by the esparto liquid. which being very foul should never be allowed to run into any stream or ditch near habitations. Collection and storage of the materials is also a source of danger to the public health. The vapours given off during the process of boiling esparto grass with caustic alkali are also offensive and should, therefore, be conducted by a flue to a tall chimney.

Industries in which Poisonous Metals are Used.

1. **Lead.**—This is a most important article of commerce. Chronic poisoning by lead is very common and originates from the slow absorption and retention of minute quantities of the metal. Workers in lead factories and those who constantly handle lead are very prone to poisoning as they generally contaminate their food by their unwashed hands. The preventive measures should consist of cleanliness on the part of the workmen with regard to dress and habits. Lemonades made with dilute sulphuric acid may be taken to form an insoluble salt of lead, and free drinking of milk may be of advantage. Meals should not be taken in the workrooms. The workshop should always be kept clean, well ventilated and free from dust. Arrangements should be made for rapid and complete collection of all fumes and dust which should be conducted to condensing chambers.

2. **Mercury.**—Persons engaged in the preparation of vermilion, barometer, thermometer, and workers in factories where mercurial salts are either prepared or handled expose themselves to the poisonous effects of the metal.

The sanitary precautions to be observed are similar to those mentioned in the case of lead. Workmen should be provided with overcoats. Special attention should be paid to the proper care of mouth and teeth and all carious teeth should either be removed or filled up. Metallic mercury vaporises even at the ordinary temperature and may produce poisonous effects; it should therefore be kept covered to lessen the emanations as far as possible. The floors should be so constructed as to render the collection of all spilt mercury easy.

3. **Phosphorus.**—It is used chiefly in the manufacture of matches, and poisoning occurs only in those who expose themselves to its fumes.

Precautions.—As far as possible the use of yellow phosphorus which is more poisonous should be discouraged. Special care should be taken for the teeth and those with carious teeth are particularly susceptible to its action. Rigid personal cleanliness should be observed and washing out of the mouth with alkaline solutions encouraged. The work should be carried out in large, well ventilated rooms and if possible in the open air. The inhalation of turpentine with a view to oxidise phosphorus is also recommended.

4. **Arsenic.**—Poisoning occurs amongst those who either handle arsenical pigments, inhale arsenical dust from wall-papers or are engaged in the making or manufacture of articles coloured with arsenical dyes, *e.g.*, artificial flowers, or those who prepare skins of animals for stuffing.

The sanitary precautions necessary are similar to those described under lead poisoning.

CHAPTER V.

SOIL.

All soil may be considered as the result of the decomposition of rocks mingled with decayed vegetable and animal matter.

It is usually divided into :—

(a) Upper or surface soil which is chiefly the outcome of decayed animal or vegetable matter forming mould or "humus." The depth of this layer varies and is thickest in forest land, but is almost absent in deserts where there are no vegetations.

(*b*) *Subsoil* which results from the disintegration of the underlying primitive rock through the agencies of gases, water, &c. The depth of these layers varies greatly.

In other words, soil is a complex mixture of mineral matter of various kinds and organic matter, animal or vegetable, living or dead.

SOIL FEATURES INFLUENCING CLIMATE AND HEALTH.

Certain features of the soil influence the sanitary conditions of the inhabitants through the climate, the air and the water. They are :—

A. **Conformation of the ground and its relation to the neighbourhood** as regards position and elevation. This depends on :—

(1) The relative extent of hills and plains,

(2) the height of the hills,

(3) the direction of the main chains of the hills,

(4) the angle of the main slopes of the hills,

(5) the nature, size and depth of the valleys,

(6) the chief watersheds, and the direction and discharge of the water courses, and

(7) the amount of plain or flat land available.

Unhealthy spots among hills are closed valleys, and places where there is stagnation of air, *e.g.*, ravines. In the tropics ravines and *nullas* are usually unhealthy, as they very often contain decayed vegetation, and a current of air may disseminate mosquitoes from such marshy places. A *saddle-back* is usually a healthy site, and so are positions near the top of a slope. Places at the foot of the hills, specially in the tropics, are usually unhealthy, as they are damp and rich in organic matter on account of the accumulation of rain water and of the excessive growth of vegetable and animal life. The Terai at the foot of the Darjeeling Hills is therefore unhealthy, and very often malarious. Depressed or water-logged places are always damp.

B. **Vegetation.**—Dense vegetation renders the soil moist by obstructing solar heat and hindering evaporation from the ground. In hot countries this serves the very useful purpose of keeping the ground cool by helping gradual evaporation through the interception of solar rays. In damp soils trees promote their dryness by abstracting moisture through the roots and evaporating it from the leaves, this evaporation being much greater than what would pass off from the ground shaded by trees. By feeding upon such matter that would otherwise pollute the water and air they act as purifying agents though indirectly. It has been estimated that an *eucalyptus* tree will absorb and evaporate about ninety times the rain fall over the area it covers. This may therefore with advantage be planted in malarious districts for the purpose of rendering the soil drier and thereby lowering the level of subsoil water permanently, thus rendering the locality healthy. Forests and brushwood protect the soil specially on the slopes from being washed away by the rains. "The growth of shrubs and brushwood along the course of a stream not only keeps the alluvial banks from being so easily undermined and removed as would otherwise be the case, but serves to arrest sediment in floods. On some parts of the west coast of France extensive ranges of sandhills have been gradually planted with pine woods, which, while preventing the inland march of the sand, have so improved the climate as to make these districts a resort for pulmonary invalids."* But sometimes they are bad for health specially in the tropics where they give shelter to mosquitoes, snakes, &c., and obstruct seriously free circulation of air, and should therefore, not be allowed to grow near dwellings. They should be cut down after the rains are over, *i.e.*, once in October, and again in December. In districts where destruction of wood has raised the temperature and lessened the amount of rains, the evil done to the climate and sanitation should be repaired as far as possible by fresh plantation. In fact there is no surer way of ruining a district than by the reckless destruction of its forests and the pollution of water supply.

C. **Ground Air.**—All the varieties of soil except the hardest rocks contain air in their interstices. Ground air is simply atmospheric air with its oxygen in part replaced by CO_2, and occasionally small quantities of other gases, carburetted hydrogen and ammonia.

The amount of CO_2 in the ground air of a particular part will depend on

(*a*) quantity of organic matter,
(*b*) permeability,
(*c*) depth, and
(*d*) temperature and moisture.

If the ground air of two soils be examined, similar as regards organic impurities, temperature and moisture, but of different permeability, the less permeable one will contain more CO_2. The amount of CO_2 increases again with the depth. This is due not to increased chemical action, nor to the presence of more organic impurities, but to the air not getting so easy vent as in the more superficial layers. Lewis and Cunningham, who investigated the ground air of the soil of Calcutta, found the amount of CO_2 at three feet as follows :—

---

* Encyclopædia Britannica, Vol. X.

January	February	March	April	May	June
6·2	5·6	5·6	4·7	4·1	5·6
July	**August**	**September**	**October**	**November**	**December**
4·0	10·2	11·3	9·7	8·8	7·0

The results are stated in Cc.'s per litre.

The sudden rise in August is coincident with high rainfall and the fall in spring according to Lewis and Cunningham is due not to diminished production but to increased loss of CO_2 in the atmosphere.

The ground air is always moving, and after a fall of rain there is a rise of the level of the subsoil water, and with this rise the air comes out to the atmosphere.

The causes of this movement are :—

(*a*) Difference in the temperature of the air and soil,

(*b*) the ground temperature,

(*c*) rainfall,

(*d*) wind pressure,

(*e*) difference in barometric pressure, and

(*f*) fluctuations of the ground air.

Foul air in the soil derived from defective drains, cesspools or made-soil may be aspirated into a house. This often happens when the air inside becomes warm and consequently rarefied and lighter. as in the case of houses kept closed or artificially warmed in cold countries. This is of great practical importance from a sanitary point of view, and can be prevented by making the floors impervious by cementing or asphalting, or building the floor on arches. Instances are on record where coal gas from leaky pipes has been known to find its way into distant houses following the track of water or drain pipes and thereby producing poisoning or explosion.

D. **Ground Water.**—The water present in the soil is divided into *moisture* and *subsoil* or *ground water.* When there is air as well as moisture the soil is merely moist and damp.

but when all the interstices are completely filled with water so that there is soil and water only, to the exclusion of air, there is a continuous sheet of water. Presence of moisture in the soil is the cause of decomposition of animal or vegetable matter which may exist in the ground. Damp soil is as a rule unhealthy. It may be produced by irrigation or by obstruction to drainage. The moisture of the soil is derived from—

(*a*) rain,
(*b*) the rise and fall of the ground water, and
(*c*) evaporation of subsoil water.

The absorbability of moisture varies with the soil, open gravel aborbs least (about 10 per cent) while sandy or peaty soils absorb most (60 to 80 per cent). Some soils, *e.g.*, hard limestone or dense clay, are practically impermeable to water, while others such as chalk, sand and vegetable clay are permeable.

The Ground or Subsoil Water.—The depth of the subterranean water in any soil varies, sometimes it is two to three feet from the surface, and in other cases as many hundreds. Probably the depth to which the water descends varies indefinitely according to the nature of the soil. The water which sinks into the soil is not permanently removed from the surface, but accumulates underneath till by the pressure of the descending column it is forced towards its natural outlets, in springs, rivers, &c.

The level of the ground water is constantly changing and the height of water in a well may be taken as an indication of the height of the subsoil water. It is liable to rise or fall according as the seasons are wet or dry. In some places it lies just near and in others far below the surface. When it is near the surface the ground above is always damp. Hence when the water level happens to be at a small depth, wells are shallow, and when at a greater depth they are deep.

The ground water is constantly moving, flowing towards the nearest water course, a river or a sea. The rate of the movement varies, and it has been estimated to be fifteen feet per day at Munich. The rate of movement is influenced by the ease or difficulty of the flow, relative density of the soil, and presence or absence of vegetation. The flow of water is severely hampered by the interference of trees, roots and smaller plants. In India the changes in the level of the subsoil water are very great. At Jubbulpur it is from two feet from the surface to twelve or fifteen feet, at Calcutta from five to fifteen feet, in Bengal it is generally from two or three feet to ten or twelve feet from the surface. To render the soil drier it is necessary either to drain the soil by laying porous drains ten to twelve feet apart at a depth of eight to twelve feet, or open the natural outflow.

E. **Temperature of the Soil.**—This varies very much with its geological formation and the temperature of the air. The daily fluctuations in the temperature of the air do not influence the soil beyond a depth of about three feet, while a depth of about forty feet is affected by annual variations of temperature. The observations made in the Punjab showed that at twenty feet the annual maximum was reached in September, while the minimum in March. The temperature of the earth increases with the depth. The rate of increase in England has been estimated to be about 1° F. for every fifty feet. As soils conduct heat in varying degrees, the absorptive power varies as well. Green vegetation lessens the absorptive power of the soil as evaporation occurs incessantly from the herbage, damp soils are colder than dry ones as the evaporation is constant. The temperature of the soil is taken at a depth of four feet.

F. **Micro-organisms in Soil.**—The garden soil and agricultural humus contain a large number of micro-organisms. They usually find in the soil all the conditions necessary for their growth and multiplication. Nutrition is derived from decomposition of organic matter, moisture, air, and suitable temperature. These conditions are found more in the superficial than in the deeper layers of the soil. Therefore a large number of microbes are found in the former than in the latter, since their number decreases at a depth of ten or fifteen feet. The microbes found in the soil are either *saprophytic* or *pathogenic*. The specific micro-organisms of tetanus, anthrax, cholera and enteric fever are also found in the soil.

The microbes are transmitted to men from the soil by wind, which blow about dust charged with bacteria, and through water when the ground water is separated by thin layers of loose soil from the surface or when the fissures allow a ready communication from cesspools, and occasionally through articles of food which grow on the soil.

The action of the micro-organisms in the soil is to carry out the process of oxidation of dead organic matters. The nitrogen of organic bodies is first converted into ammonia and then into nitrates and nitrites. Sewage is thus purified in the case of 'intermittent downward filtration'.

VARIETIES OF SOIL.

The healthiness of a soil depends on—

(*a*) good and efficient drainage of water,
(*b*) moderate vegetation,
(*c*) absence of organic emanation, and
(*d*) pure water supply.

Newsholme classifies soil as under:—

1. **Granitic, Metamorphic** and **Trap Rocks** owing to the good drainage and slope are always dry and form healthy sites for houses.

2. **Clay Slate** is equally healthy, the water supply and vegetation being less.

3. **Chalk,** when free from clay, is always a healthy soil, but with clay it is damp and cold.

4. **Limestone** and **Magnesian Limestone Rocks** have considerable slopes, so that water runs off quickly. The hard oolite is the best and magnesian the worst.

5. **The Sandstones.**—Here both the soil and air are dry, and, therefore, healthy. If the sand be mixed with clay or if clay lie under a shallow layer of sand rock, the site is sometimes damp and cold. The hard millstone grit formations are healthy.

6. **Gravels,** unless water-logged, are healthy in any depth. Gravelly elevations are the healthiest of all sites, and the water supply is usually pure.

7. **Sands.**—When of considerable depth and free from organic matter these may be considered healthy, but when they are shallow and lie on a clay basis, or when the subsoil water rises through them to a high level, they are unhealthy. They are equally unhealthy when water is found within a yard of the surface or when they contain soluble mineral matters. In the Punjab sand contains lime, magnesium, and salts of alkaline earth.

8. **Clay, Dense Marls** and **Alluvial Soils** owing to the retention of water in them are cold and damp. A clay soil will improve by thorough drainage. Alluvial characters are to be seen in the deltas of big rivers.

9. **Cultivated Soils.**—Well-cultivated soils are frequently healthy. Irrigated lands favour the breeding of mosquitoes, therefore dwelling houses should not be constructed in the vicinity of such places.

10. **Made Soil.**—When insanitary tanks, hollows or other depressions of the ground are filled up with refuse such a soil is called *made soil.* The chief point to be considered in such cases is whether the local conditions are favourable for rapid disintegration of organic matter. The complex organic substances are disposed of by the micro-organisms and are converted into harmless inorganic compounds which are finally removed by percolating rain water. Insanitary tanks or low lying lands where water can accumulate should be filled up for improving the local sanitary conditions, but to carry it out effectively and without least offence certain conditions are necessary. The refuse undergoes fermentation and putrefaction with the formation of certain gases chiefly marsh gas, sulphuretted hydrogen, &c., which may travel a long distance underneath the ground. The serious nuisance and consequent ill-health can be avoided by attending to the following points :—

(i) All such sites should be dry and in case of tanks or land subject to flooding the water must first be drained away and arrangements made to protect such areas by embankment.

(ii) The daily deposit of refuse should be covered over by a layer of good dry earth six to twelve inches deep.

This prevents the refuse from being blown about by wind, and emanation of foul vapours.

(iii) Whenever practicable such works should be completed before the onset of the rains to prevent formation of offensive puddles and breeding of flies.

(iv) Large tanks should be partitioned either by means of bamboo matting or earthen dam and each part taken in turn.

(v) The land should not be used for any purpose other than gardening or cultivation, and care must be taken to drain it.

Dampness of Soil.—Damp soil is, as a rule, unhealthy, and when permanently wet it generally contains much organic matter. To render the soil fit for habitation proper drainage for readily carrying away surface or storm water without permitting it to percolate into the soil and lands should be made. Wherever necessary subsoil drains should also be constructed to permanently lower the level of the underground water.

According to Professor Simpson the following are the causes of dampness :

(1) *Retentive Soils.*—Clay soil is difficult to drain and when the land is lowlying, swamps are easily formed which add to the unhealthiness of the locality. Alluvial soils when mixed with clay, sand and a large proportion of organic matter as met with in valleys or in lowlying lands are also unhealthy.

(2) *Impermeable Layer near Surface.*—The depth of the subsoil water should be at least five feet from the surface. When the impermeable stratum is too close to the surface it holds up the soil water very near to the surface.

(3) *Obstructed Drainage.*—Obstruction to the flow of the underground water or natural drainage of the locality brought about by embankments often gives rise to dampness and marshiness. That railways are responsible for the spread of malaria in certain districts may be best explained in the words of Professor Simpson: "Wherever railways do not follow the watershed of the district ample provision should be

made to secure diversion and sufficient outlet for the drainage which is likely to be obstructed. In all new railways in the tropics this essential factor in the health of the localities through which the railways pass should be insisted on."

(4) *Burrow Pits.*—When excavations are converted into stagnant pools and marshes they become breeding places for mosquitoes. Such excavations are generally made on either side of the railway for raising the embankment. In all such cases arrangements should be made to empty these into the nearest watercourse.

(5) *Sand Pits and Clay Pits.*—These are generally formed when earth is required for building purposes. These are very difficult to drain and add to the unhealthiness of the place.

(6) *Silting up of Streams.*—This leads to the obstruction of the natural drainage and makes the place unhealthy and malarious. As examples may be mentioned the silting up of channels in the district of Burdwan.

(7) *Neglect to Keep Clear the Water Ways.*

(8) *Introduction of Water Supply without Provision of Drains.*

Effect of Irrigation on Soil.—Irrigation makes a healthy locality unhealthy when not attended with efficient drainage. When a large volume of water is allowed to run into a district the natural outlets which may have been sufficient for its drainage prove inefficient making the soil damp and water-logged.

For the proper management of irrigation works in India without affecting the health of the district the following rules are to be observed :—

(1) The irrigation canals to be constructed along the line of the watershed.

(2) The smaller canals should be so consrtucted as not to be carried across the natural line of drainage.

(3) Drainage cuts to be constructed along the natural line of outfall.

(4) The supply of water should be limited to the amount required, and to the particular time needed to secure the success of the crops.

DISEASES ARISING FROM THE SOIL.

Diseases may be produced either directly or indirectly.

A. **Directly.**—The actual contagia or micro-organisms of diseases may be transmitted either through the subsoil water or air. In the former case the contagia find their way to the drinking water of rivers, springs, &c. In the latter it may be carried to the surface of the soil either through insects or ground air and then enter the system through dust and food. Some micro-organisms retain their vitality for a certain length of time in the soil. The chief of these are the bacilli of tetanus, anthrax, malignant œdema, enteric fever, diphtheria, &c. In cases of enteric fever, cholera, dysentery, and anthrax, the infection of the soil usually takes place from the patient.

Anthrax.—Also called *Malignant Pustule* or *Woolsorter's Disease.* This is communicable to man from lower animals. Its connection with the soil is explained by the fact that the disease occurs in epidemic form among animals grazing on damp soil infected previously with the discharge of diseased animals.

Malarial Fever.—The cause does not exist in any mineral constituent of the soil, but on the facility which a soil affords for holding surface water in which mosquitoes (anopheles) can breed.

Enteric Fever.—Pettenkofer considers that the variations of the level of the ground water in the urban area is associated with the rise and fall of typhoid death rate, and he holds that the outbreaks are favoured by—

(i) rapid falling after a rise of ground water, *i.e.*, a well ærated moist soil,

(ii) a certain temperature of the earth, and

(iii) pollution of the soil by animal impurities.

He considers that the outbreaks of enteric fever occur when the subsoil water is at its lowest. Enteric excreta when buried superficially in dry sandy soil may be carried about by air and infect food. But owing to the dry method of removal of excreta in India the majority of cases are due to conveyance of germs through dust and flies. Although most of the cases occur through water or milk infection, we have enough evidence to prove that soil is also a breeding place for enteric germs.

Cholera.—Pettenkofer holds a similar view with regard to cholera. He considers that epidemics occur when the soil is porous, and has been rendered moist by a rise of subsoil water, which allows the air to penetrate the soil during the fall of ground water with which the cholera bacilli find their way. But the observations of Lewis and Cunningham in Calcutta do not bear out the above statement. Cholera is less in September when the level of ground water is at its highest, whereas, it occurs as epidemics in the month of May when the subsoil water is on the lowest level. In India widespread epidemics occur either during or after rain which washes the cholera bacilli from the surface of the soil into wells, tanks, rivers, and other sources of water supply. It follows, therefore, that the lowlying areas suffer most from the scourge.

A certain amount of moisture is necessary for the retention of vitality of the cholera germs in the soil. Cholera frequently occurs in epidemic form in lower Bengal where the soil is usually moist. In the Punjab the soil is dry and epidemics are rare unless the soil becomes moist by rain.

It is believed that the cholera germs live longer in the superficial layers of the soil. In India the evidence is in favour of the soil being a medium for the propagation of the disease in which the bacilli retain their vitality for a long time.

Diarrhœa (epidemic or summer).—This is associated with low lying alluvial soil. The soil temperature at a depth of four feet is important and the summer rise in the mortality from diarrhœa does not commence until the temperature rises over 56° F. The annual recurrence of diarrhœal affections, specially among infants, is due to the rise of temperature of the soil and consequent resuscitation to activity of certain pathogenic saprophytes to which these diseases are due, and to the changes effected by their means in milk and other food.

Diphtheria.—A stagnation in the high level of the subsoil water, by rendering the soil damp, affords a suitable nidus for the growth and development of the diphtheria bacillus.

Dysentery.—Soil affords a temporary nidus to the specific germs and is therefore of secondary importance.

Phthisis.—The effects of damp soil in the prevalence of phthisis, though indisputable, is only indirect. Combined with cold wind, chill and moisture it might induce respiratory catarrh and thus render persons more susceptible to the attack of tuberculosis, specially if the domestic and other conditions be insanitary. But it is a known fact that agriculturists who expose themselves to cold and wet suffer to a less degree, the exposure tending to harden their system against such attacks. Phthisis is common among those who are ill-fed and live in ill-ventilated houses.

Rheumatism.—Damp soil by rendering a locality cold predisposes to chronic rheumatism, while acute rheumatism is looked upon as a specific infectious disease.

Tetanus.—Although the tetanus bacilli can live in other places besides soil, yet soil is the chief medium through which the germs are distributed.

Plague.—Observations show that the soil of an infected room or where plague-infected rats either have burrows or have died is very likely to become infected.

Malignant Œdema.—The infective agent is found in the soil impregnated with putrefying matter.

B. **Indirectly** a damp soil may cause disease by lowering the vitality and consequently the resisting power of a person. In this way neuralgia, catarrh and rheumatism are caused.

CHAPTER VI.

HOUSES AND BUILDINGS.

In selecting a site for a house the following points should be observed :—

(1) The ground must be rising and good, and not hollow.

(2) The slope of the elevated land must be sufficient and in one direction only to allow the rain water to be drained off rapidly.

(3) There must be free circulation of air, but the spot should not be too much exposed to the winds.

(4) Permeability of the soil should not be overlooked. The soil should be of a loose gravelly nature to allow free drainage. The worst soils are shallow beds of gravel or sand lying over clay, as also alluvial tracts, owing to their frequent water-logged condition. If "made soil" is used for building purposes it should be asphalted or covered by some impermeable material extending from one outside wall to the other.

(5) The building should face north and south, and the whole part should not be exposed to the sun.

(6) Vegetations round the house will keep it cool, but if they be too close they might make the house damp by obstructing light and air.

(7) Underground drainage might be necessary if the subsoil water be on a high level.

(8) The site should be at a distance from marshes, paddy fields, cowsheds, stables, &c.

(9) The surface soil or subsoil should not be polluted by sewage or other refuse.

(10) Vicinity of bazaar or bustee should be avoided and servants' quarters should be as far away as possible especially in malarious places.

(11) The surface drainage of the plot must be perfect.

(12) A site with a constant level of subsoil water is better than a place where the subsoil level varies during the different seasons of the year. The ground water should be about ten feet below the surface and not subject to sudden changes.

(13) The height of the building should not be such as to obstruct its water supply.

CONSTRUCTION OF HOUSES.

To make a house healthy it must be properly ventilated and made dry, as a damp building harbours disease. Dampness may originate from the soil on which the house stands, or from rain, leaky roofs, or from planting trees too near to the house. Bricks by their capillary attraction draw up moisture from the soil and make a house damp. Ill-ventilated and closed houses without sufficient number of doors and windows for admitting light and air also become damp. It is almost impossible in India to adequately ventilate a room by natural means unless arrangements are made for cross ventilation. Situated in narrow lanes as most of the houses in congested parts of towns are, with a narrow frontage, and wedged in between adjoining buildings, three out of four blocks are absolutely shut in save for the tiny courtyard which in lofty buildings is almost well-like. Other factors affecting ventilation of Indian houses are the *purdah* system and partition suits.

In his report on the sanitary condition of the northern portion of Calcutta for the Improvement Trust, Dr. H. M. Crake makes the following observations :—

"No survey of an Oriental city can possibly ignore the potent influence of the *purdah* system on its domestic architecture. Obviously the *courtyard house* is directly inspired by the necessity of securing absolute privacy for the ladies of the household. To effectually seclude the inner apartments from the vulgar gaze, air and light are shut out and the rooms rendered unfit for human habitation. It is very common to find the whole of the lower storey of the *zenana*, even in large and valuable houses, given up to godowns and kitchens, the inmates frankly admitting that none of the rooms are fit to live in. I must confess I am astonished at the average kitchen. It is, in a large number of houses, a gloomy, stuffy den, full of acrid smoke, and yet the ladies of the house have to spend hours in these very unpleasant surroundings. The entire absence of chimneys results in an atmosphere which is almost unbearable when cooking is going on in a particularly ill-ventilated kitchen.

Partition suits.—The curious system of actually dividing dwelling-houses amongst several co-heirs is a very potent factor in the production of insanitary property. It is quite common to come across what was originally a single dwelling split up amongst three or four relatives. Owing partly to the *purdah* system, but very largely to the bad blood engendered by the almost inevitable litigation which the partition involves, each co-sharer erects as lofty a masonry wall as he possibly can, so as to completely shut off his share from the rest. Though carried out with wonderful ingenuity, the result too frequently is that a noble mansion with spacious courtyards is converted into a number of mean little houses with totally inadequate open spaces, and most of the rooms imperfectly lighted and ventilated. Very often one unfortunate heir can only reach his portion through a long tortuous passage, the partition having resulted in the formation of an insanitary 'back-house'."

The Foundation must always be solid and substantial. When the soil is soft and yeilding, the walls should be very broad or built on a solid basis of concrete. In making the foundation the ground should be dug up, and then a bed of good cement concrete made covering the whole site of the house and extending six inches beyond the 'footings' of the walls on every side. The object of laying this bed of concrete is to prevent the entrance of ground air and moisture through the basement floor into the house. In addition to this bed of concrete a layer of impervious material, known as the "damp-proof course," should be laid horizontally for the entire thickness of each wall, above the point where the wall leaves the earth, but below the level of the floor. The materials used for this purpose must be impermeable to moisture and sufficiently strong to stand the superincumbent weight and unequal pressure, and may consist one of the following:—

(1) sheet lead,
(2) two layers of roofing slate,
(3) a layer of good asphalte two inches thick,
(4) perforated stone-ware tiles, and
(5) well-tarred bricks.

Of these asphalte has the advantage of being less costly. Efficient ventilation with dryness of the floor may be ensured by erecting the houses on arches; but care should be taken to keep the ground surface perfectly clean and dry, for, not infrequently, this is allowed to remain wet and filthy, and becomes the receptacle for dirty water, refuse, &c., and thereby greatly neutralises the good effects otherwise derived. In the absence of a dampproof course a damp line about 5 or 6 feet in height appears on the walls, even in houses raised on arches, as soon as the soil is saturated with water especially during the rainy season.

Walls.—The materials usually employed for the construction of walls of dwelling houses are bricks, stones or wood. A good brick should be well burnt, of a regular shape, of a uniform colour and when struck should give a clear metallic sound. Ordinary bricks are porous and so allow air to pass through them. The brick work of the wall should be at least 15 inches thick. Wood, unless well seasoned, should not be employed. A thin-walled house is hot in summer and cold in winter. It is necessary that the outer walls above the ground level should be so constructed as not to admit damp even if exposed to rain and wind. Hollow external walls would resist any amount of damp and they consist of parallel walls separated by an air space of about 2 inches and tied together by bounding ties of iron; but the constant presence of rats, &c., within double walls makes it difficult to prevent a nuisance arising therefrom. A good plan therefore is to fill the space between two such walls with asphalte thus forming a vertical damp-proof course.

The *chimney flues* should be properly constructed during the erection of the house walls. They should be circular, straight, and higher than the surrounding building and not made of wood or any inflammable material.

The walls of houses are mostly plastered and white or colour washed outside. The plaster used is chiefly a mixture of *chunam* (lime) and river sand. It has been the custom of late to leave the outside walls with bricks exposed, but for this, neat work with good bricks is required. Although this looks well and refreshing to the eye, it makes the buildings proportionately hotter.

The inside of walls is generally covered with plaster. Ordinarily this consists of two layers, the first is a mixture of lime and sand, and the second of slaked lime mixed with water to the consistency of cream. The treatment of this surface of the room however differs; it may be—

(*a*) *Lime washed* with quick lime and water. This acts as a germicide.

(*b*) *White washed* with a mixture of whiting or finely-ground chalk and water. Some alum or gum may be added to protect it from being rubbed off.

Oil painting is also in use. This renders the surface impervious and enables it to be easily washed. The painting of wood and iron work with oil paints is valuable not only as a preservative but also because it prevents absorption of organic matters.

Papering though extensively used in England is rather rare in India being rapidly deteriorated by the climatic conditions that prevail.

The upper floors may be made of wood, or terraced and cemented. *Floors* are best made of impervious material which can be washed. Bricks, stones, tiles, broken bricks and mortar, cement, asphalte, &c., are all in use in India. The floor of the ground storey should invariably be air and watertight. The concreted floors are usually covered with a layer of good cement, Indian Patent Stone or marble slabs.

The roofs of Indian houses are either flat or terraced, sloping or pent. Flat roofs should have just enough slope to allow rain water to flow off. Roofs should always be high as the heat radiated from a roof is in inverse ratio to the square of its distance. Flat roofs are not so cool as sloping ones and are not so well adapted for ventilation. They, however, afford a promenade and a place for sleeping in the hot weather.

Sloping or *pent roofs* may be either of tiles, slates, thatch, corrugated iron, &c. Tiled roofs are coming more into fashion with the introduction of varieties in tiles. Thatched roofs made of hay or straw, spread on a bamboo frame-work, and about six to twelve inches thick, are often used for the construction of bungalows, specially in those parts of India where the heat is great. These are very cool and dry, but their liability to take fire easily and the shelter they give to rats and other animals are the great draw backs. This may partly be obviated by occasional renewals. A double tiled roof with a space between should make a very cool covering to a dwelling. Corrugated or galvanised iron is also used as roof covering. This is very hot in summer and noisy during the rains, but is very well suited for hill stations.

The height of the rooms should be at least ten feet, and every room must have at least one window opening to the outer air direct.

Water closets or *privies* should be confined to one part of the house. At least two sides, if not more, should be open to the outside air, and the floor and walls up to a certain height should be of cement or glazed tiles.

Rain Water Pipes.—Every house should be provided with proper means for getting rid of rain water. For this purpose proper rain pipes are to be fixed. These may be either of wrought iron, tin, or earthen-ware. Those made up of wrought iron are the best. Houses with sloping roofs should have gutters all round the lower edge of the roof to catch the rain, with openings at intervals, whence the water is carried down by ordinary rain pipes.

THE HOUSING PROBLEM.

Now a days, in towns like Calcutta, various new problems as to the construction of dwellings for proper accomodation are being seriously thought of, the chief point to consider being how to obtain an abundant supply of air and light. To meet these ends either *residential quarters* or *lodging houses* are constructed.

A. **Residential Quarters.**—The following points should be taken into account in the construction of a residential flat:—

(1) The building, the drainage and the water supply should conform to the Municipal Act.

(2) The staircase, flats and pantry should be well lighted and aired.

(3) The water closet for each flat should be in a detached portion of the building, and the number should be in the proportion of one for every six persons.

(4) There should be abundance of water supply and proper arrangements for efficient drainage.

(5) Each block or flat should be complete with separate water closets, baths, kitchens, &c.

(6) There should be sufficient open space or portico for each block or flat.

(7) The kitchen should also be detached to prevent smoke from entering into the residential quarters and connected to the main building by a covered passage.

(8) The servants' quarters should be away from the house but within the compound.

B. Lodging Houses :—

By a 'lodging house' is meant a house where persons of the poorer class are received for short periods (usually at night), and although strangers to one another, are allowed to inhabit in a common sleeping room. Such lodging houses (mostly unauthorized) exist in different parts of India, specially in places where people go for a pilgrimage and stay for a short time only.

The cubic space per head in a lodging house should not be less than three hundred feet. The rooms must be properly lighted and ventilated and arrangements made for regular and thorough removal of refuse and slops. There should be a sufficient supply of good water.

BUSTEES AND HUTS.

"**Bustee** means an area containing land occupied by, or for the purposes of, any collection of huts.

Bustee Land means land in a 'bustee' which is let out for the building of huts under an arrangement by which the tenant of the land is the owner of the hut.

Hut means any building no material portion of which above the plinth level is constructed of masonry."

The *floors* of such huts are commonly of earth without any damp-proof course or bed of concrete and consequently are very damp. The plinth is usually 2 or 3 feet high and made of earth and cowdung.

The *walls* are either of wood, unburnt bricks, bamboo matting plastered over with mud, or corrugated iron or tin. The *roofs* are made either of thatch or country tiles (*khaprels*) or corrugated iron.

These huts are very unhealthy, and it would be better to consider if it is possible to improve them in any way.

It is important that all huts should have an open space or courtyard to which each room should open. They should be built on a continuous line and have ridge ventilation, but never made higher than sixteen feet. Each hut should be isolated and a space of 6 to 10 feet left between. In case of a *bustee* land the main roadway should be at least twenty feet wide for easy removal of refuse by carts. For the repair and maintenance of these huts in a state of comparative cleanliness the following points should be observed* :—

(*a*) The use of cow-dung as covering for the floor and wall should be stopped.

---

* King's Manual of Hygiene.

(*b*) The floors should be dug up and removed every few months, a layer of fresh mud must be laid again.

(*c*) Each room should have at least two windows two feet square opposite each other ; in the case of one window it should be three feet square.

(*d*) Mud walls should be white washed every four months.

(*e*) Dirty water and waste food and garbage should not be thrown in the vicinity.

(*f*) The windows and doors should be left open morning and evening for free ventilation.

(*g*) The latrine must be outside the main hut and must have an impermeable floor, easily accessible from behind for the sweeper. It must be cleaned daily and have the door and window large enough to allow plenty of fresh air and light.

Bake Houses.

In India it is rather exceptional to find bake houses built on sanitary principles. The law relating to it being very defective any room or hut may be converted into a bake house. The sanitary principles for the construction of a house where food is prepared must be rigidly enforced. A very common defect is that the floors are made of earth ; such floors are very objectionable as they do not admit of proper cleaning. It is best to have the floors cemented. The rooms should be well lighted and ventilated, and the walls, ceilings, &c., should be lime washed at least every six months, and no part of the room should be used for sleeping purposes. No water closet, privy, or sewer should communicate with the interior of a bake house.

Cowsheds and Stables.

These must be separate structures and placed at a distance of at least twenty feet from any place of human habitation. The well should be at a distance and should not be kept open but carefully protected and the water drawn by a pump. Cowsheds and stables should always be well lighted and well ventilated, and the floor should have a slope on one side and must be of some impermeable material, either brick-on-edge with cement pointing, or stone paved. A sufficient number of dust bins must be provided and arrangements made for regular removal of refuse. The drains must be plastered with cement and should lead either to a vat or a moveable receptacle of sufficient size protected from flood and rain. Each cow must have a space of 8 feet × 4 feet and a minimum air space of 600 cubic feet, each horse 9 feet × 5 feet, and each buffalo 8 feet × 5 feet. The best form of cowshed is an open one, protected only by a roof and low walls. Every cowshed, stable, or cattle shed should be thoroughly cleansed twice a day.

CHAPTER VII.

FOOD.

A food may be defined as anything which, when taken into the body, is able either

(i) to build up or repair tissues, or

(ii) to supply material for the production of heat or muscular work.

A true food must, therefore, be either a tissue builder or a source of potential energy.

Certain articles, *e.g.*, condiments, though strictly speaking cannot be classed as food, are used as accessories and help in the assimilation of food. Considering the part it plays in the assimilation, salt may also be classed as an important food.

Classification of Foods.

Milk which is the perfect food for growing children contains all the proximate principles of diet and as such furnishes an index as to what the necessary constituents of a diet should be. The functions of food as building material, fuel and supplier of energy are fulfilled by the different groups of nutritive constituents.

Proteids, water and mineral matters supply the true building material of the body. Strictly speaking condiments, tea, coffee, &c. are rather accessories to food and will be considered later on. These and the various *masalas* act by exciting the different secretions of the body concerned in digestion, stimulating the nervous system, or producing a desire for food.

The nutritive constituents of food may be grouped thus :—

- Organic
  - Albuminous or Nitrogenous
    - Proteids
      - Myosin of meat,
      - Casein of milk,
      - Gluten, Legumin.
    - Albuninoids
      - Gelatin,
      - Chondrin.
  - Non-nitrogenous
    - Carbohydrates
      - Starch.
      - Sugar.
    - Fats or hydro-carbons
      - Oils.
      - Fats, Butter,
      - Ghi, &c.
    - Vegetable Acids
      - Oxalic,
      - Citric, &c.
- Inorganic
  - Water
  - Mineral matter or Salts
    - Common salt,
    - Chlorides,
    - Phosphates,
    - Lactates, &c.

Proteids.—These are also known as *nitrogenous* or *flesh-forming* substances. They are the most important of the food-stuffs, since they are essential for the maintenance of animal life. They are composed of—

Nitrogen	... 16 per cent.	Hydrogen	... 7 per cent.
Carbon	... 54 „	Sulphur	... 1 „
Oxygen	... 22 „		

According to their nutritive value, proteids are divided into two classes :

True proteids—albumin (*e.g.*, white of an egg), myosin (from muscles), fibrin, syntonin, gluten (from vegetable proteids of wheat), legumin (vegetable proteids of dals, beans and peas), casein and globin. In them the ratio of nitrogen to carbon is two to seven. This is the most easily digested group.

The other containing less digestible matter than the first are gelatin (derived from tendons), chondrin (from cartilages), osscin (from bones), and keratin (from horns). In this the ratio of nitrogen to carbon is two to five and a half.

The Functions of the Proteids are:—

(i) They contribute to the formation and repair of the tissues.

(ii) They form the digestive and other fluids of the body.

(iii) They regulate the absorption and utilization of oxygen and play an important part in the chemistry of nutrition.

(iv) Under certain conditions they form fat, as the fat of milk is derived principally from the proteid of the food.

(v) Under certain conditions proteids supply the energy and heat and may take the place of carbonaceous foods.

Fats or Hydro-carbons.—These are compounds of fatty acids, *e.g.*, palmitic, stearic, &c., with glycerine. They are composed of carbon, hydrogen and oxygen, the amount of oxygen is insufficient to combine with hydrogen to form water.

One of the great purposes served by fat in the food is to diminish albuminous metabolism, and therefore it is called "albumen sparing food." If flesh alone be given, large quantities are required in order that nutrition and waste may balance each other, but if fat be added the demand for flesh is diminished. Fats however have an important relation in the body to the production of force and heat, and also to bodily work and bodily temperature. Unlike proteids the metabolism of hydrocarbons is independent of the amount of food taken, but is affected by bodily exercise which produces little effect on nitrogenous metabolism. In some cases fat is eaten in excess. In temperate climates an excess of fat is usually in the diet of those who do hard work, where the fat is more or less directly utilised as a source of energy. But when there is excess of fat in the diet of sedentary persons part of it is unabsorbed and passes out with the fæces, but a large amount is stored up in the body. It should be noted however that the putting on of fat in the body is not always dependent upon the amount of carbohydrates or fat in the food. In some families storing of fats depends on the special development of the fat cells, and such people get fat without the excess of fat in the food. Every body knows that fat animals stand privation of food better than thin ones ; in such cases the small store of fat is quickly consumed and the albumen is rapidly called on.

Carbo-hydrates.—These are compounds of carbon, hydrogen, and oxygen. The oxygen is present in the proportion required to form water with the hydrogen. During digestion starch, cane sugar, dextrine and milk sugar are transformed into grape sugar or glucose before they are absorbed, and in this form they are much more metabolised than the fats or proteids.

The carbo-hydrates play the same rôle as fats in food being sources of heat and energy. They are also a source of fat, but in ordinary diets they are utilised immediately as sources of energy. If it is desired to increase the albumen, without adding greatly to the store of fat, we should (according to Bauer) give more proteid and less carbo-hydrate. But if we want a substantial addition to the fat of the body the food should contain more carbo-hydrate with a fair proportion of fat.

Vegetable Acids.—Although these are not strictly speaking foods, they are necessary for the preservation of health ; the chief ones being tartaric, citric, oxalic, and malic acids. Vegetable acids are mostly derived from fresh fruits and vegetables, and by forming carbonates in the system help to preserve the alkalinity of the blood and other fluids. By oxidation they help the body to maintain a certain amount of heat and energy. If vegetable acids are withheld from the diet an altered condition of the blood associated with the causation of scurvy results.

Mineral Salts.—These are of great value to the body and are as essential to nutrition as the proteids. They include common salt, phosphates of lime, soda and potash, magnesium and iron. Of these sodium chloride or common salt is very important and occurs in all the tissues and fluids of the body. It highly promotes the diffusion of fluids through membranes, and its presence is necessary for maintaining the globulins in solution. It enters into the formation of hydrochloric acid of gastric juice and bile salts, and is absolutely necessary for existence, and its complete withdrawal from food would prove speedily fatal. A large part of it is taken in meat, bread, &c. The phosphates of sodium and potassium are important salts; the blood plasma and other fluids owe their alkalinity partly to these alkaline phosphates. Sodium carbonate and bicarbonate are also found in the plasma. They are taken in small quantities with the food and partly formed in the body by the decomposition of the salts of the vegetable acids. They carry CO_2 from the tissues to the lungs. Calcium phosphate is essential for the development of bones and is very important for the young. The best source of lime salts is milk, and next to milk is egg. Rice is also an important source of calcium. Iron is an essential element of hæmoglobin, and therefore of the red blood cells. It is also found in the muscles and in other tissues in minute quantities.

All these mineral substances are introduced into the body as constituent parts of the various ordinary articles of human food, animal or vegetable, with the exception of common salt which is usually added to various foods in greater or smaller amount in addition to what they may themselves contain.

Water.—This is an important article of diet and forms 64 per cent of our body weight. The daily loss from the system is about 100 ounces It is taken separately, as also with the solid foods which contain it. Water is necessary to compensate for the losses caused by the excretory organs, and for the repair of the various fluids and of the solid organs of the body into whose constitution it greatly enters. It is also a vehicle for the solution and dilution of solid foods whereby they are more easily digested and assimilated. The amount of water needed by the body depends on various circumstances, specially on bodily temperature and bodily labour. The greater the functional activity of the bodily organs the more is the need for water. The temperature and humidity of the air, as also the nature and amount of solid food taken, also increase the necessity for taking in of water. The need for water is indicated by thirst. Insufficient supply of water leads to disturbances of circulation, and of the heat regulating mechanism, and also to retention of products of metabolism. A free supply of water promotes circulation of fluids, accelerates albuminous metabolism and increases the activity of the kidneys with free secretion of the urine.

Necessity for a Mixed Diet.—From what has been said before it follows that the maintenance of the body in a healthy condition depends upon a mixed diet, which combines all the proximate principles, *viz.*—proteids, fats, carbo-hydrates and salts. The proteids are the principal ones as without them no vital action could be carried on ; on the other hand an excess will cause a rapid oxidation of fat. Increase of fat and carbo-hydrates lessens the absorption of oxygen. Health cannot be maintained on proteids and water alone, but at the same time a person cannot be healthy without them.

QUANTITY OF FOOD REQUIRED IN HEALTH.

It has been ascertained that no single nutritive principle would support life for any length of time and that a mixed diet is necessary.

The amount of food necessary to maintain the body in a state of health and activity depends upon a number of circumstances and can be arrived at either by a *physiological* or an *empirical* method. The physiological method is based upon estimations of the intake and output of the chemical constituents of the food, and the amount of potential energy expended daily in the production of heat and muscular work.

The empirical method is based on an analysis of the diets of healthy persons, living under known conditions.

Standard dietaries are dietaries based upon the results yielded by the first method, and those which result from the second are **actual dietaries.** It should be noted, however, that these standard diets have a very limited application, they are useful in furnishing one with some data of the amount and kind of food to be given to a healthy person doing a moderate amount of work. This is specially important in connection with the management of poor houses, schools, jails and the like. In the cases of individuals, however, certain modifying factors such as age, sex, height, build, work, &c., have to be considered.

Age and Sex.—Building material, fuel and muscle food are more needed by children than adults, because they have got to add to their tissues by growth in addition to keeping them in repair. Like all small animals they have a larger surface as compared with the bulk and so the loss of heat is relatively great, and lastly being restless and more active the muscle waste is much greater than is commonly supposed. Consequently the importance of fat and proteid in their diet can hardly be over-estimated.

Women require relatively less food than men on account of the lighter nature of their work, and also perhaps from their possessing a slower metabolism. It is generally held that a child of ten requires half as much and a child of fourteen as much as a woman.

Just as children require a large amount of food so with the aged the reverse holds good. At this age the power of assimilation is on the wane, and bodily activities on a decline and so the diet should be smaller than that of middle age. It is advisable, therefore, that one should reduce his diet after fifty, specially the proteids.

Height and Build.—The amount of food required varies with the body weight and the extent of the body surface. A heavy man requires more food than a light one. Again more heat is lost if the body surface is great and consequently a larger supply of fuel is required. A tall thin man who has a larger surface requires, if anything, more food than a short stout man, who has a much smaller surface.

Work and Rest.—In ordinary life the amount of food needed depends more upon the mascular activity than on any other factor. It has been shown as a result of experimental investigations and. experience that a greater performance of bodily labour calls for an additional supply of proteids and carbo-hydrates in the food. On the other hand during complete bodily rest, as during illness, the demand for potential energy may fall to 2000 calories or less per day. A man doing moderate muscular work requiring a supply of potential energy equal to 3000-3500 calories daily.

Mental work does not increase bodily waste to any appreciable extent, quality and easy digestibility are more needed by brain workers than mere quantity. Muscular work can therefore be done to a great extent on a diet mainly of carbo-hydrate, with only a small proportion of proteid, but brain work requires food containing a larger proportion of proteids. The comparative effect of a nitrogenous and non-nitrogenous diet in nervous energy has been well expressed in the following lines:—

> Was ever Tartar fierce or cruel,
> Upon the strength of water gruel?
> But who withstands his rage and force,
> When first he kills, then eats his horse?

Climate.—Owing to the greater loss of heat more food will be required in cold climates than in temperate ones, and more in the temperate climates than in the tropics. In very hot weather the appetite is lessened and less food is taken and consequently there is some loss of weight. It seems very probable that in cold climates and in winter the heat-supplying foods specially those rich in fat should be increased, while in the opposite condition there should be increased carbohydrate and less proteids and fats. The blubber diet of the Esquimaux and the rice diet of the Hindus are examples in point.

THE RELATIVE VALUE OF FOODS.

The relative value of different foods must be considered on chemical, physiological and economic grounds.

The *chemical value* of food is estimated by the results of percentage analyses. But the nutritive value of food cannot be judged from its chemical composition alone. While food with a small percentage of nutriment cannot be regarded as a valuable article of diet, a high chemical value alone does not imply suitability to the needs of the body.

The value of food from a *physiological* standpoint depends on the digestibility and absorbability of food.

Digestibility of Food.—This depends on two factors:—

1. The food must be in a fit state to be digested.

2. The physical and chemical conditions in the body must be appropriate.

A mixed diet is easily digested ; fat taken with meat helps the digestion of the latter. Food accessories like condiments, &c., also help in the digestion. Palatability of food is not simply a gratification of the sense of taste and pleasure. An appetizing food or even the idea of it is sufficient to make the mouth water, *i. e.*, increases the flow of saliva, and at the same time produces in the stomach what has been termed by Pawlow "appetite juice." Moreover, the increased production of saliva in its turn tends to increase the secretion of gastric juice, this again stimulates the duodenal mucous membrane and leads to the production of the hormone to which the name *secretin* has been given by its discoverers, Bayliss and Starling. As the results of experiments on men commoner foods are arranged according to the length of time which they take to disappear from the stomach.*

1 to 2 hours.

7 ozs. of water or plain tea, coffee, or cocoa.
7 ozs. of boiled milk.
7 ozs. of beef tea.
Whites of three eggs.

2 to 3 hours.

¾ pint beer or boiled milk.
A large teacupful of coffee with cream, or cocoa and milk.
2 raw poached eggs.
5 ozs. boiled white fish.
7 ozs. cauliflower or asparagus.
5 ozs. boiled or smashed potatoes.
2½ ozs. white bread.
2 ozs. biscuits.

3 to 4 hours.

8 ozs. stewed chicken.
5½ ozs. any sort of bread or biscuit.
5½ ozs. rice, apples or carrots.
9 ozs. boiled beef.

Beef, pork, mutton, boiled and roasted fowls are rather less digestible.

Absorbability of Food.—The absorbability of the food in the intestines must be distinguished from digestibility in the stomach. By *digestion* is meant the production of simpler bodies which are presented for absorption, but the actual amount of absorption depends upon certain physical factors, *e. g.*, osmosis, diffusion, &c. Therefore a food that is easily digested is not necessarily that which is completely absorbed, and *vice versa.* Carbo-hydrates and fats are more easily absorbed than proteids, and animal proteids more readily absorbed than the vegetable ones. It should be noted, however, that part of the food should remain in the intestines to act as a "ballast" to stimulate peristalsis.

---

* Green's Encyclopœdia of Medicine and Surgery Vol. II.

The *economic* consideration of food is of great value. The maxim "cheap and nasty" does not necessarily apply to food. The price of food is determined more on its rarity than on its chemical composition and digestibility. A good food therefore is one that contains high nutritive value, and is easily digested and absorbed, cheapness not negativing its qualities.

Time for Taking Food.—A diet with all the proximate principles may with advantage be taken three times a day. It has been estimated that it takes about 4 to 5 hours to digest an average European diet, and 7 to 8 hours an average Indian one. But in either case this varies with the kind of food taken. During youth, when the digestive functions are comparatively active and rapid, the intervals should be shorter than during adolescence. Indians as a rule take two principal meals, the breakfast in the day, and the dinner at night. A morning meal is always necessary, for so long a fast after the last meal at night under the modern conditions of life is rather exhausting and injurious. The body becomes more susceptible to morbid influences especially to cold, infection and other adverse influences. Again, there should be a sufficient interval between the last meal and bed time.

A certain degree of regularity in the time of taking food is important. In some cases the desire for food occurs with all the regularity of the clock, and if food be not taken at that time the appetite disappears.

The habit of eating too much is always to be condemned, the results being disordered digestion, faulty assimilation, derangement of the liver and bowels with defective elimination, and excess of effete matters in the blood. In fact the adage "leave off with an appetite" should be more strictly observed in the tropics than in the temperate climates.

Cooking of Food.

We now pass on to consider in what way these different articles of food can best be made to yield the full amount of the nutrition they are capable of affording. Of the various definitions suggested of 'man' he has been called "a cooking animal," and man is the only animal that uses fire and prepares the food before he eats it. Cooking is both an art and a science, and good cooking implies knowledge and skill. Neither bad air nor bad food is compatible with either sound mind or body. The irritability and bad temper of a hungry, weary man are allayed by wholesome, sufficient and palatable food. Cooking therefore answers most valuable purposes in connection with food. It increases the palatability of food and enables it to be more readily masticated and easily digested. By the process of cooking a number of vegetable products that would be too hard for digestion are rendered softer, and proteid foods are made more palatable and digestible. Certain pathogenic microbes with which the food may be infected are killed by this process. Cooking has very little effect upon the total nutritive value of meat, but the method affects the quantity of nitrogenous or non-nitrogenous extractives, to which the flavour is due. If meat is taken in the form of broth it must be put in cold water and then brought up to the boil; by this method the extractives get dissolved out before the outside layer becomes coagulated. If on the other hand it is desired to retain all the flavour in the meat, it must be put into boiling water, which will coagulate the surface and retain the flavoring matters as far as possible in the interior.

The accepted method of cooking vegetables is faulty to a high degree. Potatoes, roots, green vegetables, &c., are boiled in a bath of water, and this involves a great loss, as the bulk of the valuable mineral salts are drained away. Snyder and Frisbey have demonstrated that with potatoes the loss is greatest when they are peeled and soaked in water before cooking as is the common practice. By this process the total nitrogen becomes diminished by 50 per cent and proteid 25 per cent. But this loss can be reduced to almost half if the peeled potatoes are placed in boiling water at once. Boiling therefore of all operations of cookery is that which calls for the most careful judgment, and that method of boiling which causes no loss at all is the best, and this result is only attainable by cooking in dry steam.

There are at the present time many different kinds of apparatus for steam cooking, but the parent to them all was the cooking pot invented by Captain Warren, and all steam cookers are more or less built upon the Warren principle. The saving thus effected is proved by the fact that a cooked joint of meat with gravy will weigh just the same as the raw joint when put into the cooker.

Cooking therefore as shown above is almost always an advantage, but there are instances where the reverse is the case. Oysters contain a digestive ferment enough to digest themselves, but when cooked not only is this ferment destroyed but the flesh becomes tougher. Fresh milk is said to contain no less than seven ferments, some split up sugar, others digest proteids, and others again digest fat. By boiling the activity of these ferments is destroyed, and some are of opinion that in consequence of these changes boiled milk is more liable to produce a form of scurvy.

DISEASES CONNECTED WITH FOOD.

Excess of Food.—Food when taken in excess leads to certain gastro-intestinal troubles. Fermentative and putrefactive processes are set up with the generation of offensive gases leading to dyspeptic troubles. These might be attended with either constipation or diarrhœa. Some of the products of putrefaction are absorbed into the system and give rise to symptoms of auto-intoxication, *viz.*, headache, fever, a bitter taste in the mouth, fœtid breath and torpor. If fat or carbo-hydrate be in excess in the food, they seem to set up acid dyspepsia with accumulation of much flatus. Fat is also deposited in the tissues and persons suffer from obesity, not uncommon amongst the better class Indians. Besides giving rise to the above symptoms, excess of food puts an extra strain on the digestive system with the result that secretion and peristalsis are both considerably diminished. Excess of animal proteids causes an undue tax on the excretory organs and may increase a pre-existing tendency, or develop one, if it does not already exist, to gouty or other allied diseases.

Deficiency of Food.—Deficiency in all the proximate principles of diet involves loss of weight, debility, poverty of blood and prostration. Complete deprivation leads to rapid wasting, dryness of mucous membrane, impaired action of the heart and respiratory system, low fever, restlessness, delirium, coma and finally death. Young subjects bear starvation badly and die very soon. Absence of fat leads to a state of malnutrition. The lack of nitrogenous elements predisposes persons, specially rice feeders, to phthisis, pneumonia, &c. Continued starvation produces the most disastrous effects on the human constitution, and Cunningham has shown that the digestive functions become so altered and degenerated from disuse that when at last a sufficiency of nutriment is given the wasted organs cannot utilize it and the sufferer dies from inanition.

The ill-fed poor classes of Bengal often suffer from a cachectic condition characterised by chronic diarrhœa often alternating with dysentery. This was described by Chevers as *Morbus Bengalensis*. They die in a state of starvation, however well they may be fed afterwards. The inability of the system to receive nourishment is due to slow failure of the nutritive faculty after a long feeding upon poor, bad and indigestible food.

Scurvy.—This is closely related to food. The cause however has not as yet been fully ascertained. One school holds that it is due to deficiency of fresh vegetables and fruits in the dietary, while others aver that it is a sort of poisoning by the ptomaines of tainted animal food. Be that as it may there can be no doubt that this disease is associated with altered conditions of blood as evidenced by lessened alkalinity due to deficiency of neutral salts of organic acids. It is believed that long continued use of preserved food, both animal and vegetable, predisposes one to scurvy. Scorbutic patients improve when removed to healthy surroundings and put on a diet of meat, milk, and curd (*dahi*).

Scurvy-like Disease in Prisons.—This usually breaks out during the hot weather and the rains in lower Bengal. It is a kind of dyspepsia and not scurvy as lime juice makes the patient worse. A careful regulation of diet and a mixture containing bicarbonate of soda, gentian and nux vomica will often bring the patient round. The gums should be rubbed with papaya skin and washed with myrrh lotion. Papaya should be freely given to these patients, and acid *chutnies* strictly forbidden.

CHAPTER VIII.

DIET IN INDIA.*

The consideration of the subject of dietary with special reference to India is a very difficult problem. A country inhabited by many varieties of people, of different nationalities, castes, and creeds, habits and customs, physical growth and development, naturally shows a divergence in the food they eat. India, more than any other place in the globe, is endowed with the best of Nature's gifts, and no wonder, a country which enjoys unusually rich and varied soil, humid, dry, hot and cold climates, must be productive of rich herbage and yield vegetable products not to be found in any other part of the world. Hindus from time immemorial have got into the habit of living purely on vegetable diet. Although there is less prejudice in recent years against taking animal food as part of their daily diet, meat is not taken habitually by the majority of Indians. Pure vegetarians are to be met with in many parts of India enjoying the best of health. But it should be noted that milk, though derived from the animal kingdom, is not excluded from the diet of even the strictest vegetarian Hindoo; eggs, however, are not eaten by any of these vegetarians.

Nutritive Values.

Before going into details let us analyse the nutritive value of vegetable food. Based on the chemical composition alone the proteids, carbo-hydrates and fats of vegetable food are almost equal in nutritive value to the corresponding substances derived from the animal kingdom. Vegetable proteid, however, contains a smaller proportion of carbon which factor according to Chittenden makes it inferior in nutritive value to proteids of animal nature. On the other hand some German observers have shown, that the nitrogen equilibrium suffers no impairment if the proteids of meat and milk be replaced by a similar quantity of proteid in the form of peas and beans.

---

* B. N. Ghosh: *Journal of the Royal Institute of Public Health*, London, May, 1911.

As regards carbo-hydrates, it is enough to say that starch and sugar are almost entirely derived from the vegetable kingdom, and their value as food is beyond any dispute. With regard to fat absorption it has been proved by experience and experiments that vegetable fats are as valuable a means of nourishment as the fats of meat or milk.

It must not however be supposed that simply because the chemical constituents of vegetable food are equal in nutritive value to the corresponding constituents of animal food, vegetable food can replace animal food or *vice versa.* For instance, a glass of whisky is chemically the same whether it is taken raw or diluted, but the effects are markedly different. It follows therefore, that the real question we have got to consider is the question of proteid absorption of a vegetarian, for carbo-hydrates must of necessity be derived from the vegetable source.

Standard Vegetarian Diet.

Let us now consider some standard vegetarian diet and for this the ordinary jail diet of Bengal may be taken as a type which consists of :—

Rice	...	26·65	oz.	or	755·80	grms.
Dals	...	6-15	oz.	or	174·41	grms.
Vegetables	...	6·15	oz.	or	174·41	grms.
Mustard oil	...	·64	oz.	or	18·14	grms.
Condiments	...	·26	oz.	or	7·37	grms.
Antiscorbutic	...	·26	oz.	or	7·37	grms.
Salts	...	·90	oz.	or	25·52	grms.

The value of this diet in proximate principles is as follows :—

Food-staffs.	Rice.	Dal.	Vegetables.	Oil.	Total (in grms.)
Proteid ...	51·63	39·32	2·36	...	93·31
Carbo-hydrate ...	589·55	94·72	9·06	...	693·33
Fat ...	6·80	4·76	1·58	17·35	30·49

The above therefore represents the average composition of the diet in use in the Bengal jails, and according to the accepted heat equivalents its caloric value is 3,508, which is about 1,000 calories higher than is furnished by Ranke's diet. In the above diet the total bulk is so great that digestion and absorption are interfered with, and only a portion of the 93 grammes of proteid is actually utilised by the system, in fact the real nutritive value of the above diet is little more than 60 to 65 grms. But the effect of adding wheat atta, fish, or meat to the above diet, diminishing at the same time the amount of rice and dal was much better, with the result that there was a sudden rise of the proteid absorption, the actual proteid metabolism being largely augmented.

Thus on a diet consisting of :—

Rice	... 18 oz.	Atta	... 4 oz.
Dal	... 5 oz.	Vegetables	... 6 oz.

the average metabolism was 8·50 grms. of nitrogen daily. In fact the proteid metabolism was considerably increased with a diminution of about 50 per cent of nitrogen residue in the stools. The reduction of rice from 26 ozs. to 18 ozs. daily helps to bring the carbo-hydrate element and the total caloric value of the diet within the bounds of physiological limits and assists in reducing fermentation in the intestines.

It is believed that Mahomedans, who are used to animal diet are better able to absorb the proteid from an animal food than are Hindus, who are largely vegetarians. As a result of investigations by McCay* upon Mahomedans and Hindus placed exactly on the same diet, identical results were obtained. The diet was as follows :—

---

* Scientific Memoirs, Government of India. No. 37, 1910.

Bread	8 ozs.
Mutton	12 ,,
Fish	6 ,,
Rice	4 ,,
Potatoes	4 ,,

The value of this diet in nitrogen is 16·29 grms. McCay is of opinion that the degree of nitrogen absorption depends more upon the manner in which the proteid diet is made up than upon the absorptive power of the intestinal canal.

Food and Physical Development.

We are now in a position to consider the question of the relationship of food to physical development. From the researches made on the metabolism of the Bengalis and on their nutrition, it is evident "that the average native of Bengal, even the members of the well-to-do classes, exist on a metabolism of less than 4 grms. of proteid per man daily on the ordinary diet of the province." The opinion that the sociological conditions, vigour and physical development of a race are in close relation with the amount of assimilable proteid, is almost unanimous. The progress of a nation will be hampered if the citizens are ill-fed, for upon food depends not only life itself, but the power to work and to resist disease. The quality and sufficiency of food has, therefore, a far-reaching influence upon the development of the race, an influence which is directly seen in the physical well-being associated with an adequate supply of suitable food. The result of proteid starvation specially in the early growing period of life, when in addition to the elements required for repair and formation of energy, an extra quantity is required for growth, is disastrous, for this may result in imperfect growth and development, the consequences of which may be very lasting. With the rice eating inhabitants of Bengal there is a loss of tissue proteid with an accompanying loss of vigour and strength and a comparatively low capacity for prolonged or sustained muscular work. It is therefore of vital importance to consider the particular diet that will suit the people of Bengal. More assimilable proteid and not excess of carbo-hydrate, which again is one of the causes of glycosuria amongst the well-to-do classes of Bengal, is what is urgently needed in our diet. But it does not follow that proteid from meat alone should be given to build up the tissues of the body. Instances are not wanting where people show marked physical development and manliness of spirit by living exclusively on rice, atta, dal, cream, milk, etc. That there are men in India enjoying the best of health and longevity on such a diet cannot be gainsaid. But it must be admitted that the quantity of rice has to be correspondingly reduced when these are taken. The fact is, the people of Bengal living entirely on vegetable food, mainly rice and dal, for ages have got quite used to this diet. If we look to the history of the human race, we find that man has been guided in the selection of his food by the circumstances and conditions with which he has been surrounded. The physical organisation seems capable of the remarkable power of adapting itself to such food as may be procurable. Thus in Arctic regions where no vegetables can be had man lives exclusively on meat and fat; similarly in India where fruits and nutritive vegetables abound and are easily procured, these are consumed very largely.

Another side of the question must be considered here, *viz.*, there are degrees of health, and that while health and muscular strength can be maintained upon a purely vegetable diet, yet a careful consideration will show that those who live on such a diet are lacking in what is called energy. We must carefully differentiate energy from strength. The former is a property of nervous system, the latter is of the muscle. Carbo-hydrates derived from the vegetable food supply the muscles, whereas the brain requires nitrogen which is obtained from proteid food only. Energy and strength derived from animal and vegetable food are very well explained by the following lines of Haughton: "The hunted deer will outrun the leopard in a fair and open chase, because the work supplied to its muscles by the vegetable food is capable of being given out continuously for a long period of time; but in a sudden rush at a near distance, the leopard will infallibly overtake the deer, because the flesh food stores up in the blood a reserve of force capable of being given out instantaneously in the form of exceedingly rapid muscular action." One of the objections to living purely on vegetable food is that one has to consume a much larger quantity of vegetable than of animal food to obtain the necessary amount of nourishment, for as has been shown before, a large amount of proteid would pass out of the body unutilised, and the albumen of vegetable substances is often mixed up with large quantities of starch enclosed in a network of cellulose which is resistant to the action of digestive juices. Another factor which is put forward is the low resistant power of the vegetarians. This is shown by the fact that epidemics are more common amongst ill-fed vegetarians.

PHYSIOLOGICAL EFFECTS.

The physiological effects of the increased bulk of vegetable food call for some considerations :

1. The stomach and bowels become somewhat distended, as evidenced by the disproportionate development of the abdomen of herbivorous animals, and also in the so-called "potato-belly" of the Irish peasants and the fat belly of the Indian vegetarians. But this increase in capacity of the abdominal organs, by which the greater bulk of a vegetable food is compensated for, is not accompanied by an increased power of digestion and absorption.

2. The manipulation by the stomach and intestines of a large bulk of vegetable food necessitates increased muscular efforts by these organs, which implies a large expenditure of blood and nervous energy, and consequently there is less of these left for other purposes, especially for the use of the brain.

3. The increased amount of water which is an important feature of vegetable food, is also a disadvantage, for this does not lessen the intake of water, on the other hand it renders the tissues more or less flabby and dilutes the blood.*

---

* Hutchison's Food and the Principles of Dietetics.

It may be mentioned in this connexion that increased vegetable food less affects one who is engaged in out-door work than one engaged in sedentary pursuits. For a labourer requires a large amount of carbo-hydrate to perform muscular work, and the free action of the skin carries off excess of water which such a diet contains.

DAILY DIET.

Admitting, therefore, the value of proteids in the diet, and that animal proteid is the most assimilable of all, the question which naturally suggests itself is what should be the daily diet of the people of Bengal. Is it possible to live on the same diet as the Europeans do in India? Voit and Craemer pointed out that persons who have for years been accustomed to one form of diet absorb its constituents no better than those to whom such a regimen is a comparative novelty. As the result of investigations on Hindus and Mahomedans, McCay corroborates the above statement. But we find that the testimony of some experienced medical men is quite different: "It has often been said that Europeans in India should imitate the natives in their food, but this opinion is based on a misconception. The use of ages has accustomed the Hindu to the custom of taking large quantity of rice with pulses and corn. Put a European on this diet and he could not at first digest it. The very bulk would be too much for him."* Again, no less an authority than Sir Joseph Fayrer makes the following observations: "It is not advisable to copy the natives in respect of diet. Neither the mode of living nor the quality nor the quantity of the aliment can be changed with inpunity. The stomach of the Anglo-Indian will no more obtain from the dietary of the Hindu all that is necessary for nutrition than it could in other circumstances from the blubber that delights, whilst it nourishes the Eskimo." If the above is true for the Europeans, the reverse ought also to hold good for the Indians.

---

* Burney Yeo's Food in Health and Disease.

We are, therefore, unable to accept the views of Voit and Craemer, not only on the above grounds but on observed facts. Place a purely rice-eating Bengali on a European diet, and it will be seen that although he partakes of it rather greedily for the first few days, he very soon dislikes it, and his natural instinct will crave for vegetable food. Even those who are accustomed to animal food and have a great liking for meat often suffer from loss of appetite and a distaste for animal food if they are placed on European diet for some time. Further, Pawlow has shown that the pancreas pours out a secretion whose properties vary with the food supplied. If the animal is fed on meat the secretion becomes rich in trypsin, and if the diet be starchy the proportion of amylopsin in the juice becomes greater.

SUPPLEMENTING THE PROTEID ELEMENT.

We have now to consider how the deficiency of the proteid element can be supplemented. There are three methods by which this can be done :—

1. By adding a moderate amount of food derived from the animal kingdom. In meat and fish we have concentrated forms of proteid foods and by their use we can supplement the nitrogenous element which would otherwise be wanting in the diet. This diet is best suited for Europeans in India. In a suitable mixed dietary the proportion of animal food should be less than 25 per cent, and according to Voit it should be 35 per cent.

2. Some vegetarians supplement the proteid of their diet by taking milk or eggs. In fact milk and its preparations are taken by most of the vegetarians of our country. A liberal use of milk will no doubt remedy certain deficiencies of a vegetable diet, and there can be no physiological objection, except the difficulty of obtaining it pure when the question of expense has also to be considered. This form of diet with the addition of fish may with advantage be recommended for the Indian people as it will be found to agree better with their constitution.

3. For those who object to even milk, or fish, or cannot afford to have them, the only method of increasing the total proteid is by taking large quantities of such food that are specially rich in nitrogen as atta, pulses, &c. For them we would recommend the diet discussed in page 110. But the disadvantages of such a diet, necessitating consumption of a large bulk of food have already been alluded to.

A diet therefore that will suit the average people of Bengal and at the same time maintain the high standard of proteid metabolism, would be a compromise between the European and the orthodox Hindu diet. The following diet may be recommended for persons doing medium work :—

Rice ...	... 8 oz.	Fish ...	... 4 oz.
Atta ...	... 6 oz.	Vegetables	... 6 oz.
Dal ...	... 4 oz.	Milk ...	... 12 oz.
Butter or Ghee	... 3 oz.		

The approximate value of this diet in proximate principles is as follows :—

	Proteid.	Fat.	Carbo-hydrate.
Rice	0·4	0·064	6·60
Atta	0·66	0·12	4·26
Dal	0·88	0·08	2·12
Ghee	0·03	2·7	......
Fish	0·73	0·12	......
Vegetables	0·36	0·054	2·1
Milk	0·48	0·44	0·57

The following table shows the comparative value of this diet with the standard diet of Moleschott :—

	Moleschott.	Above diet.
Proteid	4·59 ozs.	3·53 ozs.
Fat	2·96 ozs.	3·568 ozs.
Carbo-hydrate	12·26 ozs.	15·65 ozs.

It should be noted that the diet of rice, wheat, lentils, &c., used by the majority of the natives of India is well suited to the climate and to their constitution. The defect in the orthodox Hindu diet is its poverty of the proteid element. Addition of wheat atta to one of the two daily meals materially improves the condition. During the hottest months many Europeans take meat very sparingly, much to their advantage. In fact there is less craving for animal food in hot weather, and also a less capacity for digesting it, specially when it is of a fatty nature.

The diet of Europeans in India should also be modified. It is not a sound practice to live on a purely European diet in India, and to try to imitate the natives of the place would be equally a folly. In a suitable mixed dietary the proportion of animal food should be less than one in four. If this is exceeded, an undue strain is imposed on the eliminatory organs and the liver. The following are the remarks of Professor Simpson on the subject : " When the Aryans first descended into the plains of India they were meat-eaters, but the experience of the centuries evidently taught them to be vegetarians, or to be very sparing in the amount of meat they ate, and at the same time to become total abstainers. This is an experience, the lessons of which the Europeans who go to the tropics are inclined to ignore. Accustomed to living well in their own country in which large quantities of meat, fats and rich food as well as wines and spirits form an important part of their diet, they are tempted to continue as closely as possible a similar diet in the tropics."

The main points that have been discussed may be summarised as follows :—

1. Vegetable food is rich in carbo-hydrate, and with some exceptions, deficient in fat and nitrogenous substances.

2. They are bulky, due to richness in starch and cellulose and to the large amount of water which they contain.

3. Some that are compact in their raw state become bulky on cooking.

4. They are less easily digested and less completely absorbed than animal food, due to bulkiness and their tendency being to undergo fermentation in the intestines, with production of acid bodies which stimulate peristalsis.

5. A vegetarian must either live upon a diet poor in proteid or consume a large bulk.

6. Either meat, fish, egg, milk, *chhana*, &c., may be used to supply the deficiency of the proteid element, and for healthy persons a moderate use of fish, milk, or meat may be of advantage.

7. Both from a chemical and physiological point of view a purely vegetable diet (milk excluded) is apt to be deficient in proteid element.

8. Best results are obtained by supplementing part of the vegetable food by animal substances rich in proteid, and this is done by taking either fish or milk or any of its preparations ; in fact two-thirds of the total proteid may safely be taken in the vegetable form.

CHAPTER IX.

VEGETABLE FOODS.

Food stuffs are naturally divisible into two groups : those derived from the vegetable and those from the animal kingdom.

The most prominent feature of vegetable food is the large proportion of carbo-hydrates which they contain, and while richness of proteid and fat is the characteristic of animal food, excess of carbo-hydrates in the form of sugar and starch characterizes the vegetable kingdom. It must not therefore be supposed that vegetable foods are merely carbo-hydrates ; they contain proteid and fat as well, and some, specially the pulses, are very rich in proteid, while others as nuts are rich in fat.

The different groups of nutritive substances which enter into the composition of vegetable foods may be analysed as follows :—

Vegetable Proteids mainly belong to the class of globulins, and are dissolved in water with a little sodium chloride. Neucleoproteids are less in vegetable substances than in the animal tissues. But vegetable proteids are comparatively poorer in carbon and richer in nitrogen.

Both animal and vegetable proteids are rendered less digestible by cooking, and it may be concluded that cooking diminishes the digestibility of animal foods and increases the digestibility of vegetable foods. This is due to the fact that animal food contains chiefly proteids, while vegetable food contains proteids to a less extent than carbo-hydrates in the form of starch, which as we shall see is rendered more easy of digestion by cooking.

Vegetable Fat is the most concentrated of all the non-nitrogenous materials that are evolved in plants, and is one of the most convenient forms in which such materials can be stored. It resembles animal fat in composition and is produced by the action of fatty acids upon basic glycerol radical. The presence in excess of the "lower" fatty acids (olein, linolein) in the substance of some of the vegetable fats results in their being of that free and liquescent condition which is known as "oil"; while, the presence, to a similar extent of the higher (*e.g.*, stearin, palmitin) in that of some other of the fats from plants causes the dense and granular solidity which is associated with the usual consistence of a fat.

Vegetable fat is of prime importance in the economy of the human race. A necessity of existence in all cold countries, fat, in the shape of oil or butter, is largely consumed as human food ; and whereas excepting olive or such other vegetable oils, the majority of fat consumed in them is derived from purely animal sources, with the exception perhaps of ghee in India, the greater number of oils utilised in the tropics are of purely vegetable origin. To the inhabitants then of all hot countries a "vegetable butter" is a product of great moment.

The popular belief that an animal fat alone is a butter is erroneous in as much as many true butters are derived from plants, and those from the cocoanut are not only by far the most important but are increasing in value day by day. Cocoanut butter is white, almost tasteless, of the consistence of beef suet or mutton tallow, and melts at about 80° F. It is cheap and claims to be superior for baking and cooking purposes to lard, tallow and butter itself.

Carbo-hydrates of vegetable food are chiefly in the form of starch and sugar. It is in the form of starch that carbo-hydrate is stored up in the plant and this abounds in all plants particularly in the seeds of cereals and legumes, and in potatoes and other tubers. Starch is more appropriately the surplus carbo-hydrate, and cannot be utilised as such by the plant. It is in the form of sugar, the soluble carbo-hydrate, that it circulates in plants. When needed by the plant, part of this starch is converted into sugar by the ferment diastase, and circulates in the plant just in the same way that it undergoes changes in the body.

Starch is not soluble in water, and thus is rendered possible its storage in the plant; further it is a more concentrated form of carbo-hydrate than sugar.

With boiling water the starch grains swell and burst and form a gelatinous solution. By the process of cooking, we break up these starch granules to be more easily acted upon by the digestive juices. Just as proteids, the nutritive constituents of meat, are enclosed in minute tubes of connective tissues, so also starch, the chief ingredient of vegetable food is enclosed in a network of cellulose. Cellulose is a carbo-hydrate but is resistant to the action of digestive juices. When old it becomes woody. It is obvious, therefore, that it must present a great obstacle to the penetration of the digestive juices.

The common forms of vegetable food may be divided into—(1) Cereals, (2) Pulses, (3) Roots and Tubers, (4) Green Vegetables, and (5) Fruits and Nuts.

I. CEREALS.

Cereals belong to the tribe of grasses, and the use of the seeds is widely spread over all parts of the globe, as a valuable article of food. Of these wheat is mainly used in Europe, maize in America, and rice and millet in India. These seeds not only contain a large quantity of nutritive material condensed in a small bulk, but also a considerable proportion of mineral substances, the most important being the phosphates of calcium, magnesium, potash, &c., with a small amount of iron and silica. The different nutritive ingredients—proteid, carbo-hydrate and fat—are represented in cereals although they are rich in nitrogenous substances, starch and cellulose, and poor in fat.

The seeds are usually ground into meal when utilised as food. This process besides reducing the hard seeds into powder, removes the outer indigestible coat which is composed of woody cellulose.

The composition of some of the common forms of cereals are :—

	Proteid.	C. Hydrate.	Fat.	Min. matter.	Water.
Wheat (atta) ...	12·24	70·92	2·18	2·24	11·83
Oatmeal ...	14·2	69·4	7·3	1·9	7·2
Barley meal ...	10·0	73·3	2·2	2·6	11·9
Rice (Burma) ...	6·95	77·2	0·9	1·34	11·13
,, (Country) ...	6·86	78·8	0·8	1·32	11·05
Maize ...	9·7	70·9	5·4	1·5	12·5
Millets ...	10·4	71·2	3·9	2·2	12·3

It should be noted that maize is relatively rich in fat and slightly deficient in salts ; rice is very rich in starch but poor in nitrogenous substances, fat and mineral matter ; oats on the other hand, are specially rich in fat and proteid, and rank as the most nutritive of all cereals. Millets are inferior to wheat in the proportion of proteids, but superior to it in fat. But the preponderance of carbo-hydrate in all cereals precludes these being used alone ; in fact they should be eaten with other foods rich in fat and proteid. As a rule these are very easily absorbed and are not only compact but possess high nutritive value, which places them in the front rank of all human foods.

WHEAT.

This is the most important of all the farinaceous seeds, and is extensively used all over the world. If a grain of wheat be cut and examined under the microscope the following may be distinguished :—

1. The germ or embryo—forming about 1½ per cent of the entire grain.

2. The kernel or endosperm—forming about 85 per cent of the grain, and consisting of two large masses of nutritive material.

3. The bran or the outer covering, this is of darker colour than the interior, and composed mainly of cellulose and mineral matters and forming about 13·5 per cent of the grain.

A grain of wheat, free from the husk, when ground between mill stones and sifted, is separable into *bran* and *flour*. Flour is divided into three portions : *Sooji* is the coarse grain derived from the outer coat of wheat and is the most nourishing ; *atta* is the next layer of finer grain ; and the fine white flour or *maida* is produced from the innermost layer. Bran, however, is not devoid of nutriment and the exclusion of it from the flour means some loss of mineral matters and some proteids from the aleurone cells.

In wheat, the ratio of nitrogen to carbon is in the proportion essential for a suitable diet. The wheat atta contains 12·24 per cent of proteid, 70·92 per cent of carbo-hydrate, 2·18 per cent of fat and 11·83 per cent of water.

Flour mixed up with water forms a tenacious mass commonly known as *dough*, from which macaroni, vermicelli, &c., are prepared. If on the other hand this dough be rubbed and washed with water on a fine sieve or muslin, there remains ultimately a white, sticky mass behind, and the washed fluid contains starch, which on being allowed to rest falls to the bottom. The sticky mass is called 'gluten' and is the chief nitrogenous element of flour. Presence of gluten in wheat helps in the formation of bread, as it has sufficient coherence to remain spongy.

Flours are of different qualities according to their coarseness, the coarsest kind being known as *pollard* or *bran flour*. Wheat atta used for the preparation of different articles of food should always be fresh. Good flour is white, but fine white flour as prepared in mills is apt to cause constipation, but is of less nutritive value containing, as it does, less mineral salts. Flour should be stored in godowns with high impervious floors.

It has often been said that 'whole meal' with all the constituents of the grain is more nutritive ; but it should be noted that the bran cells are hard and indigestible, and often irritate the intestinal canal. But it is of great value to people suffering from chronic constipation. In fact with the exclusion of bran in fine white flour, about 15 per cent of nitrogenous substances, 3·5 per cent of fat and 5·7 per cent of salts are lost. A "decorticated whole wheat meal" is now prepared where the outer or more indigestible layers of bran are separated from the highly nutritive inner tunic.

Preparations from Wheat Atta.

Bread.—This is the chief product of wheat atta, and is made by converting flour into a firm and porous substance, ready for easy mastication, and while containing some water is not moist or sticky.

Bread is prepared by first forming a dough and then imparting the necessary property of porosity either by generating within its substance or by forming from without, carbonic acid gas. Generation of gas within the dough is effected by either of the following methods :—

(*a*) By the development of CO_2 through fermentation of the flour. This method is ordinarily practised, and the bread is known as *fermented bread.*

(*b*) By mixing the dough with water previously ærated with CO_2, the so-called *ærated bread* of Dauglish.

(*c*) By generation of CO_2 from chemical agents introduced into the dough. These are so-called *unfermented bread* prepared by baking or yeast powder.

Fermented Bread.—When yeast is added to the dough, fermentation ensues, CO_2 gas is generated and is entangled by the tenacious material which swells up into a spongy mass rendering it porous and light. If at this stage it is placed into an oven and baked, fermentation becomes arrested and the whole mass hardens up into a light and spongy substance commonly known as 'bread.' The ferment generally used is yeast. When leaven is used the bread is known as *leavened bread.* Leaven is a portion of dough put aside from previous baking in which fermentative action has reached an advanced stage of activity. Fermentation is the result of a peculiar action of yeast on moist flour by which the starch is first converted into sugar and then finally the sugar into alcohol and CO_2. The alcohol generated is however driven off by the heat during baking. But unless fermentation is allowed to go on for some time, a heavy loaf will be the result.

Unfermented Bread.—Under this head is included such bread as is vesiculated by the use of baking powders for the evolution of CO_2 gas. Many forms of powders are in the market, but they all depend on the action of some alkaline carbonate, either soda or ammonia, with an acid as hydrochloric, tartaric, or citric. A great amount of private or domestic baking is carried on the same principle, butter-milk and bicarbonate of soda being used, when lactic acid of milk combines with soda and generates CO_2 gas. Although it serves the purpose very well, it appears that the chemicals less used for culinary purposes, the better.

Ærated Bread.—When CO_2 instead of being generated by fermentation within dough is separately prepared and incorporated with flour and water, *œrated bread* is produced. This method was first introduced by Dr. Dauglish. The advantages claimed for this method are :

(*a*) It does away with fermentation and other chemical changes resulting therefrom.

(*b*) Its results are certain and uniform.

(*c*) It does away with the use of alum.

(*d*) It is absolutely clean and sanitary, as it requires no handling.

(*e*) The bread is said to keep sweet and good for a longer time than fermented bread.

By the process of baking the structure of the crust or the outer part of the loaf is changed and a substance known as "assamar" is developed which retards tissue waste.

A good bread contains about two-thirds of its volume of gas, and of the solid part about 45 per cent consist of water.

It is said that baking increases the digestibility of bread, the nitrogenous constituents are changed, and the starch granules are ruptured. Well baked bread should have a yellowish brown crust, should be uniform in texture, and be permeated by minute cavities, but without eyes or large air cells. The colour of the crumb, except in whole meal bread, should be white and the bread should be free from acidity and sourness. With some stomachs even the best fermented bread disagrees, and for them the ærated bread may be recommended.

Newly made bread is soft and tenacious, stale ones crumble readily into separate particles. Being more palatable and sweet new bread, however, is generally preferred to stale; but it is less digestible. as it gets clogged together during mastication, and when swallowed reaches the stomach in non-porous lumps and consequently is not so easily acted upon by the saliva and the gastric juices. This is obviated by toasting, which renders the bread more friable and allows it to be more readily acted upon by the digestive juices. Toasts should be thin and crisp and eaten soon after they are made. Weight for weight, bread is one of the most nutritious of all our foods, and the fact that it is always eaten with butter, makes up for the deficiency of fat.

Certain substances are often used as adulterants in the preparation of bread, the chief being alum. It is used to make the bread look whiter, but it also helps in the formation of a good dough when the flour used is either old or produced from badly ripened grain.

Chappaties.—These are non-ærated hand-made unleavened breads prepared by first making the dough and then spreading it over a smooth surface. They are of a circular shape and of thickness varying from that of a thick paper up to half an inch. Chappaties are fried dry on a frying pan and then baked over fire. Prepared from good flour they are light and white, and when properly baked they are blown out with air in the centre. During this process the starch granules swell and are made ready for easy digestion. Chappaties should always be eaten fresh and rejected when more than one day old. When kept for some hours they become hard and difficult of digestion. As a rule they are eaten smeared with ghee, thus making up for the deficiency in fat.

From *Sooji* is prepared *Halowa* by cooking it with ghee, sugar and water. It is highly nutritious but not so easy of digestion and often gives rise to acidity.

RICE.

This is most widely cultivated in the East and forms the staple food with the Indians. In reality it is paddy deprived of the husk. Different varieties of rice are to be had in the market, but the principal ones are Burma and Country rice. Rangoon rice, or the so-called "*white rice*," is prepared from the unhusked paddy which is milled by machinery, and the husk with the pericarp and the outer layer of the grains are subsequently removed, and consequently it is smaller in size than Country rice.

Country rice, on the other hand, is prepared by soaking the paddy in water for about 30 to 40 hours, and then transferring them into covered jars or cylinders where they are steamed for about 5 to 10 minutes. These are finally removed, and dried in the sun. This 'parboiled' rice is then roughly husked, but a large amount of pericarp is still retained. It will be seen that in the preparation of Rangoon rice the grains are deprived to some extent of their outer layers, and consequently lose a certain amount of proteid and mineral matters, specially phosphorus. Country rice, however, retains these outer layers, and, therefore, weight for weight contains more proteid than Burma rice. Parboiling renders the rice grains tough, but portions of the pericarp still remain even after husking.

Of all the cereals rice is poorest in proteid, fat and mineral matters. Its chief constituent is starch, and this exists in extremely digestible form. About 2½ ozs. cooked by boiling requires 3½ hours for disposal by the stomach. But it should be noted that it is not the function of the stomach to digest carbo-hydrate. It only performs the mechanical part and prepares it and sends it on to the intestines for final disposal. In the intestines rice is very completely absorbed. Being insipid and only rich in starch, rice is as a rule taken with condiments and other food rich in nitrogenous substances, as pulses, fish, ghee, &c., to supply the deficiency in proteid and fat.

Good rice should be entire, clean and well-husked, and non-fermenting. It should not be mixed with any calculi or earth. It should preferably belong to the last harvest but one before, as new rice is apt to cause indigestion and diarrhœa. Rice which has been sown on swampy grounds and which has not been transplanted and which comes to maturity at the close of the rainy season, frequently gives rise to gastro-intestinal troubles.

Rice should be stored in dry and well-ventilated rooms having impervious floors. When kept in hot and damp places, it ferments and becomes mouldy with production of toxins and it is believed that this toxin is a factor in causing *Epidemic Dropsy.* Rice can be preserved by occasional exposure to the sun and by mixing lime with it. Active fermentation may be detected by putting the hand inside the bag of rice when it will feel warm.

Rice under kept " boils thick in the grain and is so gummy that the grains stick together, but when of good quality and condition the grains elongate remarkably by boiling; they do not stick together, and they have a pleasant mealiness in the mouth" (Chevers).

Rice is not infrequently tampered with by traders and old and new rice or rice of different qualities are often mixed together, and chalk powder and lime usually added to give it an uniform appearance.

Cooking of Rice.—Rice should be thoroughly washed in cold water before being cooked. Boiling is the common method of cooking, when the rice grains swell and become soft. These are then strained and the water thrown away. By the process of boiling, some of the proteids and mineral salts are lost. The more economical method of cooking rice is by steaming, as then the proteid and salts are not dissolved out.

Partly boiled paddy keeps better and is probably more wholesome, though less white in colour than ordinary raw table rice. New rice can be cooked in about half an hour while old rice takes almost double the time and keeps good for more than twenty-four hours after cooking.*

Khichri.—In this process rice and dal are boiled together to a thick consistency with the addition of ghee and condiments. In the preparation of khichri the water is not rejected. This is not only highly nutritious but palatable and appetising.

Barley.—This is very nutritious and is characterized by its richness in mineral matter. The Greeks and Romans of old trained their athlets on barley. It is rich in nitrogenous matter, which exists in the form of casein and albumen, but the amount of gluten present is very small, and consequently barley meal is not so well suited for making bread.

The grains deprived of husk form *Scotch* or *Pot Barley*, but when all the integuments are removed and the grains are rounded and polished, they form *Pearl Barley*, and when ground to powder they are sold as so-called *Patent Barley*. It is chiefly in the form of pearl or patent barley that it is used as human food.

Malt is barley in an incipient stage of germination.

Maize or **Indian Corn** (*Makkai*).—This ground to powder forms part of the diet in some parts of India and in certain Indian jails. It contains, according to McCay, 9·55 per cent of proteid, 66·20 per cent of carbo-hydrate, 2·30 per cent of fat, and 11·50 per cent of water. It is deficient in gluten and does not form bread, but like oatmeal, when mixed with milk, eggs, and other flours, forms wholesome and nutritious puddings and cakes. As it contains a large amount of fatty or oily matter it is used for fattening animals. Decomposed maize is said to produce *pellagra*—a general non-febrile disease accompanied by skin eruptions.

Corn Flour is maize flour that has been deprived of its peculiar flavour by a weak solution of soda. It was formerly believed that makkai is less digestible than wheat atta, but recent investigations have proved that proteids of makkai atta are, under the same conditions, as well assimilated as those of wheat atta. 90 per cent of its dry matter are absorbed as against 82 per cent of wheat.

---

* McNally.

Oats.—These form a highly nutritious food, and though rich in nitrogenous principle they are not considered equal in nutritive value to wheat flour. Oats are deficient in gluten and, therefore, cannot be vesiculated and made into light bread. They are not so easily digested by those unaccustomed to their use. In the form of porridge, oatmeal is very widely used, and makes a nutritious and agreeable beverage in the form of gruel. With some, oatmeal gives rise to a certain amount of heating effect, which is said to be due not so much to the presence of nitrogenous substances as to a special substance to which the name "avenin" is given. This is not so well suited to persons with a gouty diathesis as it increases the formation of uric acid.

II. PULSES.

Pulses belong mostly to the leguminous order, and are richer in nitrogenous substances than any other vegetable food. This they owe to the presence of vegetable proteid, commonly called legumin or vegetable casein. Pulses are used in India chiefly in the form of dals, of which there are many varieties, *viz.*, moong, mattar, arhar, &c. Owing to their richness in proteid pulses are sometimes called "Poor man's beef," indeed for the large proportion of proteid they contain pulses are used in conjunction with other foodstuffs rich in starch as rice. The nitrogenous ratio in the case of the pulses varies from 1-2 or 4. Pulses also contain salts of potash, lime and sulphur. As compared with cereals, these are less easily digested, and are apt to produce a feeling of heaviness, and not infrequently give rise to much flatus. Galen said "they are harder to digest and give rise to bad dreams."

The composition of common forms of pulses are :—

	Proteid.	C. Hydrate.	Fat.	Water.	Mineral matter.
Peas (green) ...	4·0	16·5	0·5	78·1	0·9
,, (dry) ...	21·0	61·4	1·8	13·0	2·60
Beans (dry) ...	25·5	56·4	1·7	13·1	3·3
Lentils	23·2	60·4	2·0	11·7	2·7
Kalai	22·58	58·02	1·10	10·87	3·61
Moong	23·62	53·45	2·69	10·87	3·57
Gram	19·94	51·13	4·31	10·07	3·72
Arhar	21·67	54·27	3·33	10·08	5·50
Mussur	25·47	55·03	3·00	10·23	3·33
Soy bean... ...	32·9	33·1	18·1	11·0	4·9

Most of these are taken cooked, and the green ones may be eaten raw. Lentils contain a large amount of nitrogenous substances and are rich in iron and phosphate of lime and have the advantage over peas in not containing sulphur, and thus not giving rise to the objectionable hydrogen sulphide in the intestines. Khesari dal (*Lathyrus sativus*) gives rise to a train of symptoms when taken for a long time, known as Lathyriasis. The symptoms are spastic paralysis of lower limbs and muscles of the thigh with increased knee jerk. But when these are taken boiled the above symptoms do not appear. The disease is very common amongst the poor, who live chiefly on powdered khesari dal.

Pulses should be well washed and husked before cooking. In the absence of animal food, they are usually taken with rice, and being poor in fat they may with advantage be used with other fatty foods, *e.g.*, bacon and peas either boiled, or cooked with ghee or oil. They are rich in purin bodies, and should, therefore, be avoided by persons with a gouty diathesis.

III. ROOTS AND TUBERS.

These may be regarded as reserves of nourishment for the use of the plant itself, chiefly in the form of starch; proteid and fat being practically absent. Tubers are largely used as food, but are much inferior to either cereals or pulses in the nutritive value, containing as they do a relatively large amount of starch and very little proteid. Of the small amount of nitrogenous material a large proportion is in the form of amido-bodies which have little or no nutritive value. These are, therefore, not suited to form the main part of any diet. Root tubers, however, are not without mineral matters, chiefly salts of potash, and the presence of these gives them a greater value as an article of diet than they would otherwise be entitled to possess.

Digestibility of root tubers depends largely upon the amount of cellulose, but, as a rule, they are very indifferently absorbed and are prone to derange the stomach and intestines, if consumed in large quantities.

Composition of some of the common forms of roots and tubers :—

	Water.	Proteid.	C. Hydrate.	Fat.	Ash.	Extractives.
Potatoes ...	76·7	1·2	19·7	0·1	0·9	1·4
,, (boiled) ...	73·8	—	—	...	...	......
Carrots ...	85·7	0·5	10·1	0·3	0·9	1·0
,, (cooked) ...	93·4	0·53	4·47	0·17	0·14	... ..
Turnips ...	90·3	0·9	6·8	0·15	0·8	1·1
,, (cooked) ...	97·25	0·32	1·67	0·06	0·32	......
Radish ...	90·8	1·4	4·6	0·1	0·7	......
Beetroot ...	83·9	0·5	14·0	0·1	0·9	1·0
Onions ...	89·1	1·6	8·3	0·3	0·6	......
Sweet Potatoes	72·9	1·6	24·3	0·5	0·7	......

POTATOES.

The potato is universally used as a wholesome, palatable and popular article of food of much nutritive value. Opinions are at variance as to how far by itself the potato is capable of sustaining life and vigour for any length of time. On the other hand potatoes supplemented by a small amount of some other food containing nitrogenous material, such as milk or fish, supply to a large number of people a diet containing all that is necessary to maintain health and strength.

The potato is a valuable antiscorbutic, chiefly due to the various salts which it contains, specially citrate of potash. Valuable and wholesome as the potato is, it is nevertheless unsuited for weak stomachs. In fact this is one of the most common articles of food which the physician has to withhold from his patients, and this is chiefly due to the large amount of starch that it contains. The digestibility of potatoes depends also on the form in which they are eaten. Mealy potatoes are more easily digested than waxy. But on the whole potatoes are well absorbed in the intestines, due to the fact that they contain more starch than cellulose.

Cooking of Potato.—Potatoes are eaten either boiled or fried in oil, ghee or butter, and as such they are rendered more palatable. During boiling the albuminous juices are coagulated, and the starch granules absorbing water swell up and the cells in which they are contained break down, with the effect that the potato assumes a mealy or floury appearance. When mealy, potato is easily digested, and new potato being less mealy is not so easily digested. Dry heat, as by baking, converts the starch into a soluble form and finally into dextrose.

Steaming is better than boiling, but the skin should not in either case be previously removed. The chief defect in boiling is that the nitrogenous constituents are often dissolved out. Further, potato boiled in its jacket is digested one hour earlier than when boiled without the skin ; this is due to the fact that it loses none of its juices or salts which help digestion.

Sweet Potato.—It may be used in place of ordinary potato. It is rich in starch (16 per cent) and sugar (10 per cent). When boiled it becomes very soft and can be mashed easily, and forms a wholesome and useful food.

Arrowroot.—This is a preparation from the tuber of *Maranta Arundinocea*, containing about 88 per cent of pure starch. It forms a pure and simple starchy food of a bland unirritating character, valuable for invalids.

Sago and **Tapioca.**—Sago is obtained from the pith of *Sagus feriniferus.* The starch grains are large, irregular, with ill-defined concentric lines. Tapioca is also pure starch obtained from the tubers of *Manihot utilissima.*

Sago, arrowroot and tapioca are all agreeable and easily digestible forms of pure starchy food, used chiefly for invalid cookery. They are also used in the preparation of puddings, &c. Alone they have a very limited nutritive value, but may with advantage be added to either milk or soup, which are richer in proteids. They rank amongst the most completely absorbable of all foods.

Carrots, *beetroot*, *radish*, &c., are all roots of a succulent character, and are used as fresh vegetables. Beetroot is used mostly in salads and often boiled.

IV. GREEN VEGETABLES.

These have a very low nutritive value, and are used not so much for their nutritive principles as on account of the important alkaline salts which they contain. Most of the salts are eliminated as carbonate and may with advantage be used by persons with a tendency to gravel. Some give an agreeable flavour to the food and help digestion, and are useful as condiments. Besides these their antiscorbutic properties are valuable, and they are therefore always essential in a dietary.

They form an agreeable diversity of our food and give relish to other foods. Green vegetables consist of leaves, buds, young shoots, leaf stalks and often the entire plant. These contain a large amount of water (about 90 per cent), and the nitrogenous material is very small, (from 1 to 4 per cent) and of this again about half only consists of proteid. The deficiency of fat is often made up by cooking them in oil or ghee, and thus prepared they act as valuable vehicles for carrying fat into the system. Green vegetables are rich in cellulose which offers a resistance to the action of digestive juices, but the indigestible residue in the intestines acts as a "ballast" and stimulates the intestinal action; consequently they are of great value in cases of chronic constipation. Vegetables should have the stalks and midribs removed before being prepared for food, and the cooking should be thoroughly performed to separate the fibres. It should be noted that the real nutritive value of fresh vegetables which is very low to start with, becomes still less by cooking, and a large part of the remnant which reaches the intestines escapes absorption.

The following is a list of some of the commonly used vegetables :—

	Water.	Proteid.	Fat.	C. Hydrate.	Mineral matter.	Fuel.
Cabbage ...	89·6	1·8	0·4	6·9	1·3	165
Cauliflower ...	90·7	2·2	0·4	5·9	0·8	175
Tomatoes ...	94·3	0·9	0·4	3·9	0·5	105
Celery ...	94·5	1·1	0·1	3·3	1·0	85
Water cress ...	93·1	0·7	0·5	3·7	1·3	...
Cucumber ...	95·4	0·8	0·2	3·1	0·5	80
Asparagus ...	94·0	1·8	0·2	3·3	0·7	105
Lady's finger...	90·4	1·96	1·1	5·72	0·8	...
Brinjals ...	93·98	0·89	0·94	3·48	0·26	...
Plantain or Banana ...	75·3	1·3	0·6	22·0	0·8	460
Red gourd ...	93·40	0·90	1·0	3·96	0·7	...

From the above it is evident that most of the vegetables contain a very small proportion of carbo-hydrate, and so they may be used in cases of diabetes, specially as carriers of fat. Asparagus has a diuretic effect, and imparts a peculiar odour to the urine due to a volatile sulphur compound produced from it in the intestine (Hutchison). Onions, garlic and many of the lily tribe are used chiefly as condiments for flavouring foods. The volatile oil present is excreted with the various excretions, and imparts its characteristic odour to the breath, urine, &c.

Cauliflour is more easily digested than any other form of vegetables and may be used for dyspeptics. Cucumber is very indigestible, and often sets up bowel troubles, but its agreeable flavour and cooling properties have given it a great popularity. It is often eaten as salad with vinegars lemon juice, salt and pepper.

V. FRUITS AND NUTS.

Fruits form a large class of vegetable food, and as they act more as baits to attract insects or birds to ensure liberation or transportation of the seeds, the æsthetic quality predominates in most of them. From the nutritive point of view, fruits are divided by Hutchison into "Food Fruits" and "Flavour Fruits." The latter are used chiefly for the sake of sweetness and flavour. Like fresh vegetables fruits are of use by reason of the important mineral salts they contain, which exist chiefly in the form of salts of potash combined with vegetable acids. In certain diseased conditions, these mineral salts are of great value. The nutritive value of fruits depends on the presence of carbo-hydrate, which exists in the form of sugar, and is commonly known as *levulose* or fruit sugar. It is a point of practical importance that fruit sugar is to a certain limit more easily assimilated by diabetics.

The difference in all fruits as regards the digestibility depends on the nature of the fruit and the degree of ripeness. Certain chemical changes take place during the process of ripening. As the process begins, the fruits cease to grow, absorb carbon and give off oxygen, acids and astringent substances become less, and the starch is converted into sugar. Excess of acids present in the unripe condition often irritate the bowels, and may set up diarrhœa and colic.

Of the different varieties of fruits—grapes, bananas, mangoes, &c., are important and deserve more than a passing notice.

Grapes are of great value in as much as their use is directed to various purposes. The juice of ripe grapes contains grape sugar, bitartrate of potash, tartrate of lime, malic acid and water, but the amount varies with different varieties. Grapes are largely used as food, and are among the most agreeable, wholesome and nutritious of all fruits. Being refreshing and cooling they may be taken by invalids, but the skins and the seeds should always be thrown away, for they are apt to set up irritation of the bowels.

Dried grapes are called *raisins*, and contain more sugar and less acid and are less digestible. With milk they are often taken as gentle laxatives.

The plantain or banana belongs to the class of *food fruits.* These are most extensively cultivated in India. The fruits grow in clusters, and each cluster often contains about two hundred fruits, and weighs from 40 to 60 pounds.

Plantains are largely eaten in India both when green and ripe. The ripe plantain forms an agreeable and delicious fruit, and is often used at dessert. The skin is rather thick and may easily be stripped off when ripe, and the edible portion is soft and spongy, and rich in saccharine and nutritive matter. In the unripe state it is used as a nutritive article of food often with other vegetables. Dried and ground to powder it constitutes what is called *plantain meal* or *banana flour.* This is used as a nutritive food specially suited for invalids. It contains proteids 4·0 per cent, fat 0·5 per cent, carbohydrate 80·0 per cent, mineral matter 2·5 per cent, and water 13·0 per cent.

"Bael," fresh or in the form of sherbet or *morubba,* is very useful in dysentery and forms a cooling and agreeable drink in hot weather. It also acts as a mild laxative.

The mango is one of the most highly prized of all fruits. It is palatable and nutritive. When unripe, it is used to make pickles, tarts and preserves, and sweetened with sugar it is made into "chutney." When ripe it is wholesome and agreeable, and is most extensively used in its season by all classes of people. Mangoes cause looseness of the bowels and should not be taken when there is diarrhœa. Dried mango slices are known by the name of *Amchur*, and it is said to be also of use in scurvy.

In addition to the above, pineapples, melons, cucumbers, apples, apricots, &c., are all used and form delicate fruits for the table.

Nuts differ from the above fruits in that they are of higher nutritive value, but are not so easily digested, not that they are rich in fat but that they contain much cellulose. In fact the real nutritive value of nuts is so great that they can very well replace meat.

Cocoanuts, walnuts, almonds, &c., are very widely taken in India. Nuts, containing as they do less carbo-hydrate, are better suited for diabetics. Cocoanut water is cooling, and refrigerant, and is a very useful drink during fatigue and thirst. The milk obtained from the ripe kernel by scraping and pressure is rich in fat and proteid. The kernel is a valuable food and is utilised in the preparation of different kinds of Indian delicacies.

Fruits keep the action of the bowels regular, and act as valuable antiscorbutics. Oranges, lemons, papaya, &c., are valuable in this respect. Papaya is also of value in helping the digestion of proteids, and for which purpose green papaya is often used.

Preservation of fruits is often resorted to, and this is done by means of syrups, and keeping them in hermetically sealed cans. Mangoes, lichis, pineapples are preserved in India and exported to foreign countries. Pears, apricots, &c., are preserved in Europe and sent out to India.

MUSTARD OIL.

Mustard oil even more than butter, ghee, or fat, is extensively used in India, specially in Bengal. It enters into the dietary of most of the people of Bengal both rich and poor. In fact it is the only source of body fat with the poor, who can ill afford to take either milk or ghee, in their dietary. The essential oil which it contains, imparts to the food, a flavour not obtainable by any other oil.

Mustard oil is prepared by process of expression of the seeds, of which there are three varieties, the colza (*Brassica dichotoma*), the rape (*B. glauca*), the rai (*B. junce*). The yield of the oil varies, roughly one maund of mustard seeds will produce about 15 seers of oil.

Useful as the oil is, it is nevertheless extensively adulterated. Excepting those manufactured in jails the oil is adulterated with some form of mineral oil (Batch oil or Bloomless oil). The oil seeds usually employed as adulterants are *surguja* or niger seeds, poppy seeds, *til* or sesame oil (*Sesamum indicum*), ground nut oil and mohua oil (*Bassia latifolia*), &c.

CHAPTER X.

ANIMAL FOODS.

Animal food contains all that is essential for the growth and maintenance of our body.

MEAT.

This consists of muscle fibres held together by connective tissue. The fibres contain muscle plasma or muscle juice, and this is made up of water holding in solution nitrogenous substances, salts, and extractives. The salts are chiefly chlorides and phosphate of potash. About 15 per cent of ordinary butcher's meat is inedible, being made up of cartilage, tendon, &c.

The **proteids** of meat are myosin, muscle albumin, and hæmoglobin. *Rigor mortis* is due to the clotting of myosin, which makes the meat tough. But acids are very soon developed in such a meat which soften the myosin, and make the meat more tender and give it a better flavour. Meat should therefore be eaten after rigor mortis has passed away.

The *connective tissue* of meat yields gelatin on boiling, this is aided by the acids developed in meat on hanging, and this gelatinization is the result of conversion of cholagen. The acids which are developed later improve the flavour of the meat, but these are present even at the time of death of animals which have undergone great muscular exertion before death. Hence the flesh of hunted animals is of superior value.

Connective tissues are more abundant in the old animals than in young ones, consequently the meat of old animals require more cooking.

Fat is often imbedded in the connective tissues, but the amount varies in different animals. In pork the fat is in excess, whilst in partridge and chicken it is almost absent. Fat so placed hinders digestion and absorption of meat. But the fatter the meat the poorer it is in water; in other words fat replaces water but not the proteids. It may be stated that 1 lb of meat contains $\frac{3}{4}$ lb of water, and $\frac{1}{4}$ lb of nutriment.

The amount of *hæmoglobin* varies with different varieties of meat. As it contains iron, hæmoglobin is of value in supplying that element.

Extractives are substances contained in solution in the meat juice. The real chemical composition of the extractives is not well understood. They have none of the nutritive value of meat, but are of use in giving the peculiar flavour and taste.

In slaughtering an animal for food, it should be bled immediately it is knocked down. Although this involves some loss of nutritive materials, this method is justified as it improves the appearance and delicacy of flavour, and prevents rapid deterioration.

The percentage composition of the most important animal foods used in the tropics are given below :—

	Proteid.	Fat.	Carbo-hydrate.	Salt.	Water.
Beef (average) ...	20·96	5·41	—	1·14	72·03
Mutton ...	17·11	5·77	—	1·33	75·99
Fowl (lean) ...	19·72	1·42	—	1·37	76·22
Fish ...	16·0	5·0	—	1·0	78·0
Milk (cow) ...	4·20	3·70	4·50	0·7	86·0
Cheese, (Dutch) ...	28·21	27·83	2·50	4·86	36·60
Eggs ...	12·55	12·11	0·53	1·12	73·47
Butter (fresh) ...	2·00	85·00	—	1·00	12·95

INSPECTION OF ANIMALS.

Animals must be kept under observation in a stock yard or cattle mart for at least 24 hours, preferably longer, before being slaughtered. During this period they must be fed and watered. They should not be too old nor too young. The composition, flavour, digestibility, &c., of meat differs with the species, age, sex, and part of the body. A good ox should weigh between 600 to 1200 lbs. and be from 2 to 8 years of age. In India a gram fed sheep weighs about 35 lbs. and yields about 18 lbs. of food, and an ordinary country sheep weighs about 25 lbs. The weight of an animal in pounds can be determined by the following formula :

$$\tfrac{2}{3}(5L \times G^2)$$

L=the length of the trunk from front of the scapulæ to the root of the tail.

G=the girth or circumference just behind the scapulæ.

Add to the weight thus obtained $\frac{1}{20}$th of the weight for very fat animals, and deduct the same amount for very thin ones.

The animal is divided into carcass and offal ; the former includes the whole of the skeleton with the exception of head and feet, with the flesh, membranes, vessels and fat as well as the kidneys and fat surrounding them, while the latter the head, feet, skin and all internal organs except the kidneys. 60 per cent of the total weight of an animal can be utilised as food, and 5 per cent more in case of fat animals.

The age of an animal can approximately be determined from the teeth and the rings on the horns, but the dealers often file the horns.

In all healthy animals the muscles should feel firm and compact and the parts between the two buttocks should stand out prominently and the ribs be well covered with flesh. The principal indications of health are : ease of movement, quick bright eyes, nasal mucous membrane red, bright and moist, tongue not protruding, respiration regular and easy with no foul odour in the breath, circulation tranquil, skin glossy and smooth, and excreta normal.

When diseased the hairs stand out and are not smooth, the nostrils are dry and covered with frothy excretions, the eyes heavy, the tongue furred and hanging out of the mouth, respiration is difficult and movements are slowed. There may also be diarrhœa or scanty and bloody urine. In febrile conditions the ears and feet and in milch cows the teats are hot.

Of the infectious diseases the most important are pleuro-pneumonia, cattle-plague, swine fever, actinomycosis, foot and mouth disease, anthrax and tuberculosis.

Inspection of Meat.—Meat should in the tropics be inspected soon after the animal is slaughtered and the following points noted :—

(*a*) The quantity of bone is about 17 to 20 per cent of the meat as sold in England, but in India the proportion of bone is greater. The bones of young animals are brighter in colour and of old ones harder, whiter and marble-like in appearance.

(*b*) The quantity and character of the fat varies with different animals and different parts of the same animal. The quantity of fat in fat oxen is $\frac{1}{3}$, in pigs $\frac{1}{2}$, in fat sheep $\frac{1}{2}$, and in lambs $\frac{1}{8}$, of the flesh. In badly fed animals the quantity of fat may be as low as 1 per cent.

Characters of good Meat.—The following are the characteristics given by Dr. Letheby in his "Lectures on Food" :—

1. It is neither of pale pink colour nor of a deep purple tint, for the former is the sign of disease, and the latter indicates that the animal has not been slaughtered, but has died with the blood in it, or has suffered from acute fever.

2. It has a marbled appearance, from the ramification of little veins of fat among the muscles.

3. It should be firm and elastic to the touch, and should scarcely moisten the fingers ; bad meat being wet, sodden and flabby, with the fat looking like jelly or wet parchment.

4. It should have little or no odour, and the odour should not be disagreeable; for diseased meat has a sickly, cadaverous smell, and sometimes a smell of physic. This is very discoverable when the meat is chopped up and drenched with warm water.

5. It should not shrink or waste much in cooking.

6. It should not run to water, or become very wet on standing for a day or so; but should, on the contrary, be dry upon the surface.

7. When dried at a temperature of 212° or thereabouts, it should not lose more than 70 to 75 per cent of its weight, whereas bad meat will lose as much as 80 per cent.

Particular attention should be paid to the examination of the flanks, shoulders, diaphragm and the region of the kidneys. The pleura, peritoneum and the parieties should be free from adhesions or staining. In fact all the viscera should be carefully examined for signs of disease.

Cysticercus callulosæ and *Trichina spiralis* are found in the muscles. To find out trichina a thin section of the muscle should be placed in the liquor potassæ for a few minutes till the muscles become translucent when the coiled embryo is seen inside the capsule.

Diseases produced by Unwholesome Meat.– Good meat decomposes readily in the tropics. It is advisable, therefore, that it should not be kept long but cooked and eaten the same day that the animal is killed. Particular care should be taken for the proper storage of meat which should be protected from flies, cockroaches and other insects.

Meat, if decomposed, irritates the gastro-intestinal canal and gives rise to symptoms of ptomaine poisoning, *viz.*, nausea, vomiting, abdominal pain, diarrhœa, severe prostration and collapse. Urticarial and erythematous rashes very often develop, or there might be fever and delirium. By cooking the microbes are destroyed, but symptoms of poisoning are due to the products of decomposition—the toxins, and it is now believed that poisoning by meat is due to infective organisms of the coli group and their toxins. Meat kept in a dark, damp and ill-ventilated room with access of sewer gas, may develop poisonous properties. Similarly meat of animals killed by arsenic or other poisons may produce toxic symptoms.

The flesh of animals suffering from such diseases as anthrax, small-pox, general tuberculosis, &c., should be condemned with those killed by accidents and lightning. The flesh of pigs infected with *Cystecercus cellulosœ* and *Trichina spiralis* should be avoided. *Distomum hepaticum* is very common in the sheep of India.

In investigating a case of food poisoning first make a note of every article of food that has been taken by the members of the affected family. Then determine by a process of exclusion the particular articles of food that have been consumed by the sufferers in common. These articles must be traced and secured, and the validity of the finding should be confirmed by feeding experiments on any of the lower animals.

Tuberculosis in Animals.—Cattle, pigs, poultry, and rarely sheep suffer from this disease. In the early stage the meat of the affected animal is normal and fit for human consumption. The Local Government Board in England have adopted the following recommendations of the Royal Commission on Tuberculosis as a guide to Meat Inspectors in the inspection of tuberculous carcasses of cattle :—

(*a*) When there is miliary tuberculosis of both lungs (*b*) When tuberculous lesions are present on the pleura and peritoneum (*c*) When tuberculous lesions are present in the muscular system or in the lymphatic glands embedded in or between the muscles (*d*) When tuberculous lesions are present in any part of an emaciated carcase	The entire carcase and all the organs may be seized.

(*a*) When the lesions are confined to the lungs and the thoracic lymphatic glands (*b*) When the lesions are confined to the liver (*c*) When the lesions are confined to the pharyngeal lymphatic glands (*d*) When the lesions are confined to any combination of the foregoing, but are collectively small in extent	The carcase, if otherwise healthy, shall not be condemned, but every part of it containing tuberculous lesions shall be seized.

Preservation of Meat.—Meat is preserved by first cooking and then keeping in sterilized and hermetically sealed tins. Uncooked meat is preserved by

(i) drying, which is done by cutting up the meat in strips and exposing it to sun and air,

(ii) smoking,

(iii) refrigeration,

(iv) freezing, and

(v) preservatives.—The most commonly used preservatives are either antiseptics or ordinary coarse salt. Boracic acid, salicylic acid, formalin are the antiseptics generally used. Their careless use is attended with the greatest danger to consumers and should therefore be forbidden.

The utility of applying heat or cold for this purpose is thoroughly appreciated. By these processes meat is preserved without addition of anything likely to be injurious. Heat is applied in the preservation of tinned meat, the high temperature destroys all germs and spores. In a refrigerator meat is often preserved in a raw state at a temperature of 1°C. but it must be cooked a few hours after removal. The cold does not affect the freshness or nutritive value of meat in any way.

Cooking of Meat.—This is done for the purpose of developing flavour and improving the appearance of meat by destroying their colouring matter. It sterilizes the meat and lessens the risk of infection by any pathogenic germs or other parasites which may be present. It diminishes the amount of water even when meat is boiled. The connective tissue must as far as possible be converted into gelatin but meat being a bad conductor, the heat must be applied slowly and the process consequently must be prolonged. Part of the extractive matters are removed by cooking, and this occurs to a certain extent even in process of roasting. The preservation of the extractive matter to which it owes its flavour is achieved by putting the meat in boiling water which coagulates the outside layer, and prevents the escape of the flavouring ingredients as far as possible. The extractives are the chief constituents of soup, which has none of the nutritive value and yields no potential energy, although it seems to relieve a feeling of fatigue. As it tastes and smells agreeably, the soup aids digestion and is useful in the beginning of a meal.

Digestibility of Meat.—Both the mechanical and the chemical part of digestion is performed by the stomach, and thereby the chief nutritive constituent of meat (proteid) is rendered fit for absorption. During the process of digestion the fibres swell up and become soft, they change their colour, and the whole mass becomes pulpy. These changes depend on a variety of circumstances, according as the fibres are harder or denser, and thicker or longer. Cooking has some influence on digestion, and Jessen has found that beef disappears from the stomach at different times depending on the method of cooking, thus :—

Raw beef ...	... 2	hours
Half boiled ...	... 2½	,,
Wholly boiled ...	... 3	,,
Half roasted ...	... 3	,,
Wholly roasted ...	... 4	,,

It appears from the above that cooking lessens the digestibility of meat.

COMMON FORMS OF MEAT.

Beef.—It is very extensively used being cheaper than mutton. But the flesh varies in quality and according to the part used; rump, sirloin and fore ribs being considered the best. Beef is more strengthening, but requires strong digestive powers.

Mutton.—This is more easy of digestion and is widely used in India. Its fibres are shorter and more tender, but it contains larger proportion of fat than beef does, and is consequently not suited for invalids. According to Jessen $3\frac{1}{2}$ oz. of raw mutton were digested in the same time as an equal weight of beef. The flavour and digestibility often depend upon the breed of the sheep, and their pasturage.

Pig.—This is comparatively less used in India as Hindus, Mahomedans and Jews do not take it. On account of the large quantity of fat it contains, pork is the most difficult of all meats to digest; $3\frac{1}{2}$ oz. requiring 3 hours for digestion as against 2 hours for beef. Bacon is more digestible as the fat is in a more granular form. Like all fat meat, pig contains less water. It is usually taken boiled with other lean meats like turkey, chicken, veal or with eggs and vegetables, like peas, beans, &c. The pig is liable to be affected with *cystecircus* of T. Solium forming "measles," and this measly pork gives rise to a form of tape-worm—T. Solium. It is further affected with *trichina spiralis* causing the disease known as "trichiniasis."

"In the tropics generally the pig is a foul feeder and scavenger, and hence is considered not suitable for food. Its flesh is known at times to have produced intestinal disturbances. The Chinese are very fond of pork, but they generally cook it well." (Simpson).

Goat.—This is very largely used in India specially by the Hindus. Its fibres are shorter, more tender than either beef or mutton, and contains less fat, consequently goat flesh is more easily digested. Goat is immune to tubercular diseases.

Poultry and Game.—These are very favourite forms of food; but in general aspect the flesh differs from that of ruminating animals. The flesh of birds differs from that of mammals in not being permeated by fat, consequently it is easily digested. The food on which these birds are fed makes a great difference in the character of the flesh. The flesh of the fowl, guinea fowl, turkey and partridge are white, tender, of delicate flavour and easy of digestion: the flesh of ducks and geese are darker, and is well-known to disagree with delicate stomachs. Game birds contain less fat than poultry. Of game birds there are many varieties in all parts of India, and these are largely employed and esteemed as wholesome and delicate food. Partridge, snipe, quail, pigeon, wild fowl, &c., have distinctive characteristics of their own.

Fish.

Fish forms an important part in the ordinary food supply of India. It has a very high nutritive value, though not so stimulating as meat, but in general it is less rich in fat than ordinary meat. The flesh of many fishes has a peculiar odour, and the different kinds vary greatly in their nutritive value, quality and digestibility. There are two classes of fish, *fat* and *lean*. Those that contain less than 2 per cent of fat are known as lean fish; "Kai" or climbing perch (*Anabas scandens)*, and "Magur," belong to this group. Those containing 2 to 5 per cent of fat are grouped as fat fish; "Hilsa" or Indian Herrings, and "Topsi" or mango fish belong to this class.

Fish is poorer in extractives and therefore less stimulating than meat, but as it is digested more rapidly it is specially suited as invalid food, where stronger kinds of animal food are not so well digested. *Lean fish* is easy of digestion as the fibres are shorter and there is a comparative absence of fat. *Fat fish* on the other hand is very difficult to digest and the oil is apt to get rancid and cause irritation of the stomach. Dried or salted fish is less readily digested than fresh ones, and the larger ones less than the smaller or younger ones. According to Chittenden and Cummins, digestibility of fish in general is less than beef.

Absorption of fish takes place like meat, about 95 per cent of total solids, 97 per cent of proteid, and 90 per cent of fat entering the blood, so that fish ranks amongst the most fully absorbed of all foods.

It is popularly believed that fish is a valuable brain food owing to the excess of phosphates that it contains. Many authorities doubt this statement and are of opinion that this depends more upon the ready digestibility by persons of sedentary habits than to any other factor, and that there is no justification for the statement that fish is rich in phosphorus.

As a source of energy, its value depends on the amount of fat it contains, fat fish being equal in this respect almost to moderately fat meat. As a source of building material, fish is inferior to meat as it contains less proteid. The belief that fish possesses aphrodisiac properties is a mistake; in fact there is do evidence in its favour, and on the other hand some authorities have pointed out that maritime populations are not specially prolific (Hutchison).

Shell Fish.—Allied to fish are lobsters, crabs, shrimps, prawns and oysters, and they are very popular as articles of diet. These have high nutritive properties but are less digestible. Sometimes however they produce symptoms of a poisonous or irritating nature, such as nausea, vomiting diarrhœa, giddiness, &c., and frequently to erythematous rash. As mentioned before oysters when eaten raw are more easily digested than when cooked. The universal custom of adding vinegar, pepper, salt, onions, &c., stimulates the secretion of gastric juice and aids digestion.

Inspection of Fish.—Fresh fish is firm to the touch and if held by the hand the tail should not droop. The condition of fresh fish should be always in a state of rigor mortis, *i.e.* should not be soft or pulpy. The eyes should be clear and bright and not dull or sunken. The gills should be of a bright red colour. If decomposition sets in the body becomes flaccid. The skin should be intact and the scales not easily detachable in a sound fish. Soon after death the blood of fish coagulates; when decomposition begins the blood, on cutting the fish, will run out as a dull red liquid of an offensive odour. If on removing the bones a dull red mark at the points they touched the flesh is noted it indicates that decomposition is well advanced. Mussels and oysters become unfit for food very soon after death.

To avoid rapid decomposition fish should be cut and eviscerated soon after being caught. It may be sent to distant places packed in ice.

Many parasites live in fish, but only one, *Bothriocephalus latus*, can be conveyed to man.

Poisoning by fish sometimes occurs giving rise to symptoms of ptomaine poisoning. Oysters frequently give rise to urticarial rash and when taken from sewage-contaminated water may carry cholera or typhoid infection. In certain seasons specially during spawning the fish ceases to be wholesome and acquires poisonous properties. According to Simpson Indian mackerel and sardines on the Malabar coast are sometimes poisonous, and often the Bombay oyster causes serious illness when taken out of season, or when not absolutely fresh.

Tinned Fish.—This is often dangerous in tropical climates for it not infrequently gives rise to symptoms of ptomaine poisoning of a very serious nature. If required they should be bought from well reputed and respectable firms that do not deal in old stocks. They should be eaten within two months of their importation to India as decomposition usually starts after this period. Provisions imported between the months of March and October should be avoided as the hot voyage deteriorates their quality.

When making a purchase see that the tin is new, clean, not indented and that no fluid is leaking out. If decomposition sets in, the putrefactive gases will cause the two ends of the tin to bulge out. Fraudulent dealers let out this gas by making a hole and solder it up again. This is detected by the presence of two soldered holes.

If on making an opening, the liquid contents spirt out, it indicates that putrefaction has commenced ; if on the other hand, the outside air is sucked in with a hissing sound the contents are sound and fit for human consumption. On opening the tin the whole of the contents should be taken out at once. The process of drying, salting, pickling and smoking are commonly employed for preserving fish. At any rate they are unfit for dyspeptics or invalids. Sardines salmons, herrings, oysters, &c., are extensively imported to India; of these sardines owing to the amount of oil contained in the tin are less likely to cause ptomaine poisoning and are much better than other freshly packed tinned fishes, specially salmon.

Cooking of Fish.—This depends upon the kind of fish used. Oily fishes are best boiled and this makes them more wholesome. Frying in oil is the common practice with the Indians. The secret of frying consists in sudden exposure of the fish to a very high temperature, which has the effect of coagulating the protieds on the surface; and any escape of soluble substances is thus prevented. Cooking of fish should be avoided on either brass or copper vessels. Where copper vessels are used they are usually tinned inside, commonly known as "kalai", but this should be always of tin and not an amalgam of tin and lead. Aluminium and iron vessels are better and less dangerous than copper ones, for in presence of acids like vinegar, lemon, &c., copper forms a compound, acetate of copper, which is a powerful gastro-intestinal irritant, whereas with aluminium it forms alum which is simply astringent, and, therefore, harmless.

Eggs.

Egg is a typical example of food containing all the proximate principles necessary for the growth and development of the body. It is however deficient as regards carbo-hydrates. An ordinary hen's egg weighs about 2 ounces; of this about 12 per cent consists of shell, 58 per cent of white, and 30 per cent of yolk. The shell consists of carbonate of lime, and the white with the yolk consists principally of nitrogenous elements. The white is made up of a solution of various proteids, the chief being egg albumen. The yolk contains a large quantity of fat and a considerable proportion of lecithin, a proteid vitellin, and other organic compounds of phosphorus, amongst them a neucleo-proteid and an organic compound of iron. The yolk containing less albuminous matter does not so readily solidify with heat, and from containing large quantity of oily matter floats in the white.

The comparative analysis of a hen's egg is as follows :—

	WATER.	PROTEID.	FAT.	OTHER NON-NITROGENOUS MATTER.	MINERAL MATTER.
White ...	85·7	12·6	0·25	...	0·59
Yolk ...	50·9	16·2	31·75	0·13	1·09

The absorption of eggs in the intestines is almost complete, only 5 per cent of residue being left. The value of one egg as food is equal to half a tumbler of milk and the potential energy yielded amounts to 70 calories.

It is a known fact that mineral matters are more readily absorbed when they exist in organic combination. Hence iron in the yolk of eggs is absorbed very easily. Yolk of egg is therefore a valuable food for anæmic patients. It is also very rich in calcium; in fact, except milk, no food contains so much lime salts in such an assimilable form. Eggs are free from purin or purin-yielding bodies, and may be recommended for gouty people; but it is generally believed in India that the habitual use of duck's eggs predisposes one to rheumatism.

Digestibility of eggs depends upon the form in which they are eaten. Raw eggs are not all digested in the stomach; this is perhaps due to the fact that being bland they hardly excite gastric secretion. The following table from Hutchison will show the length of time eggs remained in the stomach under different conditions of cooking :

2 eggs lightly boiled	1¾ hours.
2 eggs raw	2 ,,
2 eggs hard boiled	3 ,,
2 egg omlette	3 ,,

If hard boiled eggs be finely divided and masticated they could be disposed of as easily as soft boiled eggs.

Eggs are preserved for a long time by preventing the entrance of the air through the pores, either by packing in saw-dust or salt, or by thoroughly smearing the shell with gum, butter, oil, or by placing in lime water to which a little cream of tartar has been added.

Decomposed eggs are detected by placing them in a salt solution (about 2 oz. of salt in a pint of water) when they float. Fresh eggs are always heavier than stale ones and when held up to a candle or a light are transparent in the centre while the stale ones at the ends.

MILK.

Milk is nature's own manufactured food. It is an ideal food, and is the chief diet for children up to the age of 18 months. It is in reality an emulsion of fat containing proteids, salts and carbo-hydrates in solution in water. The average percentage composition of various kinds of milk commonly used by man is given in the following table :—

Kind of milk.	Proteid.	Fat.	C. H.	Salts.	Water.
Human	2·97	2·90	5·87	0·16	88·0
Cow	4·0	3·7	4·8	0·7	86·8
Buffalo	4·4	9·0	4·8	0·8	81·0
Ass	1·79	1·02	5·50	0·42	91·17
Goat	3·62	4·20	4·0	0·56	87·54

In milk we have the different classes of alimentary principles necessary for health, but the relative proportions are not so well suited for adults under normal conditions, excessive amount of water and albuminoids inducing too active metabolism.

Of the different varieties of milk it has been proved beyond doubt that ass's milk is superior to any preparation of cow's milk in rearing premature and feeble infants, notwithstanding its deficiency of fat.

During digestion the gastric juice curdles the milk ; the curdling is due to the change brought about in the casein by rennin. The milk becomes at first jelly-like, but the curd shrinks and a yellow fluid called *whey* is squeezed out. The curd consists of casein and fat or cream, while the sugar, the soluble albumins and other salts, remain dissolved in the whey. The casein of cow's milk forms dense and hard curd, whereas the coagula of human and ass's milk are softer and flocculent. The curds later on are changed into albumoses and peptones by the digestive ferments.

The density of the clot which the milk forms in the stomach depends on :—

(*a*) the amount of casein in the milk,
(*b*) the degree of acidity in the stomach,
(*c*) the quantity of lime salts present.

All these factors are affected by dilutions, and for this purpose plain water, or better still, barley or lime water may be used. The former mechanically entangles the particles, and lime water, besides being alkaline, has a specific power in preventing clotting. Wright has shown that citrate of soda will prevent coagulation of milk by converting soluble lime salts into insoluble calcium citrate. Æration by the use of sparklets is an important factor in avoiding clotting.

The *proteids* of milk constitute about 3 per cent of the total weight, they are caseinogen and lactalbumin, and they are present in the proportion of 1 of casein and 1·7 part of lactalbumin in cow's milk. Caseinogen is a pseudo-nucleo-albumin, and differs from albumen in being coagulated by heat. It is however readily coagulated by weak acids and rennet. Casein is kept in solution along with phosphate of lime.

The chief *mineral matters* of milk are phosphate of calcium, (which occurs partly in combination with citric acid and the rest as phosphates), sodium and potassium, chlorides, magnesium phosphate and a very small quantity of iron. Stockman has shown that 5 pints of milk are required to supply the necessary amount of iron for an adult every day.

The *fat* of milk is suspended in the albuminous fluid in very minute particles in the form of an emulsion, and constitutes about 3½ to 4 per cent of the total weight. But the amount varies with the needs of the animal. When milk is allowed to stand for sometime the fat rises to the top as cream. Good milk contains about 8 to 12 per cent of cream. The separation of cream is hastened by addition of water. Skimmed milk from which the cream has been removed contains about 1 per cent of fat, and is not of much value for healthy people but is better adapted for weak stomachs. As it contains all the nitrogenous elements it is far more nutritious than whey.

The *carbo-hydrate* of milk is lactose or milk sugar, it is slightly sweet but extremely hard and gritty. This is present up to 4 to 5 per cent. It remains dissolved in the fluid after casein and the fat globules have been separated. It is not prone to alcoholic fermentation, but when it is exposed to the air for some time and specially if it be warm, certain chemical changes take place, and the sugar is converted into lactic acid. This change is due to the introduction of an organism *Bacillus acidi lactici* from without, and causes the milk to turn sour.

The quantity of milk consumed by a community is an evidence of its importance as an article of food. About 43,000 gallons are imported in Calcutta daily. But the milk sold in the Calcutta markets as cow's milk is a fluid largely mixed with buffalo's milk. The milk of buffalo has a larger proportion of total solids and fat than cow's milk and admits of larger dilution with water. It is, therefore, not so digestible and not pleasant to take. The intermixture of such a milk. so highly rich in fat and coagulable casein, with cow's milk renders it unfit as infant-food.

Goat's milk is also in common use in India specially for infants. As a rule, it is richer in cream, but poorer in proteid matter than milk of the cow. On the other hand human milk and ass's milk are richer in sugar than cow's milk.

The richness, the colour and the flavour of cow's milk varies with the character of the food on which the animal is fed ; it also varies with the time of milking and the number of times of milking. The common practice is to milk twice, but milking three times a day is not uncommon. The first part of the milk contains more water, while the last part is rich in fat. The character of the milk also varies with the class and race. In some the milk is comparatively thicker ; during the rains milk is as a rule thin, and in winter much thicker. It is important when infants are fed on cow's milk that it should be derived from the same animal, and care taken to select a cow whose milk agrees best with the child.

In India the places where the cows are kept are usually filthy, and the process of milking is disgraceful. The admixture of the dung, from the flanks and the udders of the cows and the hands of the milkers not only causes early souring of the milk but it becomes positively infected. Before milking, therefore, the udders and the milker's hands should be thoroughly washed and wiped dry.

The use of humanised cow's milk in place of, or in addition to, breast milk is not uncommon, and it is necessary that the difference between the two should be carefully noted. Breast fed infants get their nourishment direct from the mother, at a suitable temperature and adequately mixed without any exposure to the air. The milk contains no adulterants or preservatives and above all is bacteriologically clean and pure. Bottle fed infants on the other hand, get their milk which has passed through hands, and has been exposed to endless risks of contamination in buckets, pails, cans, jugs, &c., and admitting for a moment that it was neither skimmed, watered, nor otherwise adulterated, yet after being exposed to the dust of the streets, and to filthy surroundings of dairies, &c., it arrives in varying degrees of staleness, more or less polluted and charged with microbes. Without going into the details as to the nature of these organisms, it might be said that this partly accounts for the high rate of infant mortality in Bengal, specially in Calcutta.

Diseases due to Milk.—Milk becomes sour and decomposes rapidly after casein is deposited. Very often from decomposition of the proteids ptomaines are formed which are the principal factors of poisoning from ice creams, especially when stale milk enters into their preparation. Certain micro-organisms render milk unfit for human consumption; some of these cause fermentation while others change the colour. The presence of certain fungi gives the milk a blue hue, and this milk gives rise to severe gastric disturbance.

The bazar supply is always suspicious as the vendors usually adulterate the milk with water of tanks and wells, which is often infected, and causes diseases like typhoid and cholera.

Milk is one of the best culture media for pathogenic bacteria. The only important communicable disease common to man and cattle is tuberculosis. An enormous proportion of milch cows are more or less affected, and it is believed that unless the mammary glands are involved there is no evidence of their milk being infective. Attention was directed by American authorities to the fact that *T. bacilli* can be nearly always detected in the fæces of tubercular cows, and this even in the absence of clinically recognisable symptoms or signs of the disease.* It is, therefore, obvious that there must be a grave danger of contamination of milk when proper care is not taken to obtain it under cleanly conditions.

The following points should be carefully observed to avoid this:—

(*a*) The cow about to be milked should be first properly groomed to remove dung from its sides and belly, and the udders should be properly washed.

(*b*) The tail should be secured to prevent flicking cow dung attached to it into the bucket during milking.

(*c*) The floors of milk-sheds and approaches to the sheds should be paved so as to prevent finely pulverised dung from being blown into the milk during the process of milking or while it is being carried from the milk-shed.

Epidemics due to infected milk supply have the following points in common:—

1. The outbreak is sudden, so also is the cessation.
2. A number of cases occur simultaneously.

---

* The Australasian Medical Gazette: January, 1911.

3. Several members of the same family or house are attacked at one and the same time.

4. The average number of cases in each house is greater than what might have been ordinarily. An average of two attacks in a house may be considered high.

5. There will be found a common milk supply among a large proportion of the infected houses.

6. The rich people usually suffer more as they consume more milk than the poor.

7. Attacks are rare in families which take little or no milk.

8. Children are more frequently attacked than adults. This specially happens in an outbreak of enteric fever.

9. Stale milk is more dangerous than fresh milk.

Adulteration of Milk.—The value of milk as an article of diet in India cannot be over-estimated. Just as meat is to the Europeans so is milk for the Indians. It is of vital importance that the supply should as far as possible be pure and wholesome. But unfortunately adulteration is the rule, and pure supply is found only under exceptional circumstances. The adulterants commonly used are :—

1. Water, which is very often polluted.

2. Cane sugar or *bátásá*, a preparation of treacle.

3. Cream is very often removed and water added subsequently to maintain the specific gravity ; or the evening milk after being robbed of the cream is mixed with the morning milk.

4. Starch, flour, or arrowroot are often added to milk.

5. Milk of different animals are mixed together, *e.g.* that of buffalo with cow's milk.

Preservatives in the form of borax, acid boric, formalin, &c., are not as a rule used in India.

Tests :—1. Lactometer. This is a somewhat satisfactory guide so long as the milk is adulterated only with water. But if sugar is added, or if water is added after skimming then its determination cannot be taken as a reliable index of the character of the sample. The examination should be made at a temperature of 60° F.

2. When milk adulterated with water is placed in a white vessel, a pale blue line can be seen where the surface of the milk touches the vessel. This can easily be detected by the naked eye so long as the amount is about $\frac{1}{5}$ of the total volume of the milk.

3. Watering is detected by the low specific gravity, and by the diminution in the amount of cream. The specific gravity of normal milk is from 1027 to 1034.

4. Sugar as an adulterant is detected by adding equal quantity of diluted hydrochloric acid and a few grains of powdered resorcin to the milk and heating it when a blood red colour is produced.

5. The presence of starch is detected by adding a solution of iodine, which colours it blue.

6. Fat in milk is detected by the Lactoscope.

Preservation of Milk.—Milk can be preserved by:

1. Pasteurization, *i.e.* raising it to a temperature of 167° F. for half of an hour.

2. Addition of peroxide of hydrogen, and heating to a temperature of 51° C. for three hours.

3. Drying it by passing through over-heated rollers so as to reduce it to a fine powder. Water is added just before use.

4. Addition of antiseptics, *e. g.* formalin, boric acid, &c.

Effects of heating Milk.—The first effect that is noticed in boiling milk in an open pan is the formation of a thin skin on the top, which is called the cream. A portion of the casein becomes entangled with fat and finally forms part of the skin. When heated for some time milk becomes thicker in consistency, brownish in colour, and altered in taste. This change in colour is due to the charring of sugar, and this thickened milk, commonly known as "Khir" is widely used in India as a delicacy. But the most important effect of boiling milk is that it is rendered sterile.

Digestibility of Milk.—It should be noted that milk though a fluid is rendered practically solid when it reaches the stomach. The clotting is due to the presence of rennin in the stomach, but its value in process of digestion has not been worked out. Indeed Hutchison has shown that if milk could be so prepared as to prevent clotting in the stomach, its digestion in the intestines is in no way interfered with. In fact removal of the stomach does not hinder digestion of milk. Boiled milk clots less readily than fresh milk, but this happens only outside the body, as the acid of the gastric juice redissolves some of the lime salts. Digestibility of milk, therefore, depends on the density of clots in the stomach. The formation of large dense clots can be avoided by taking milk in sips, when the milk is broken up in the stomach and does not form hard clots. It has been found that it takes about 2 hours for a glass of milk to leave the stomach, but the condition of milk has a great influence on the duration of its stay in the stomach, thus :—

602 c.c.	(about a pint)	raw	leaves in	3½	hours
,,	,,	skimmed	,,	3½	,,
,,	,,	sour	,,	3	,,
,,	,,	boiled	,,	4	,,

Digestion of milk becomes complete in the intestines by the pancreatic juice, which acts more powerfully on milk than gastric juice. Absorption of milk is more or less complete ; in fact the proteid and fat are absorbed as well as, or even better than, the proteid and fat of beef (Hutchison). But when milk forms the only diet of an adult it is not so readily absorbed. Under normal conditions about 90 per cent of the available potential energy reaches the blood. It may be mentioned in this connection that milk is absorbed with less expenditure of energy—in other words, there is less wear and tear of the intestines—than any other food.

Brunton considers that fresh milk contains not less than seven ferments, and by boiling the activity of these ferments is destroyed (see page 105), and some authorities believe that in consequence of these changes boiled milk is more apt to produce a form of scurvy.

CONDENSED MILK.

Condensed milk is extensively imported to India, and is widely used specially by Europeans. Condensation is effected by evaporating the water by gentle heat. This is accelerated by the reduction of atmospheric pressure in so-called vacuum pans, and is carried so far that the volume of the milk is reduced to about quarter. Condensed milk therefore represents four times its volume of fresh milk. It is very good when a fresh supply cannot be obtained, or when the supply is suspicious.

The majority of these milks is sweetened with sugar which helps their preservation, and too often the milk is not pure as the cream is generally removed, and the product is really *Condensed Skim Milk.* The following are the different varieties of condensed milk found in the market:—

1. Condensed whole milk (sweetened).
2. ,, ,, ,, (unsweetened).
3. ,, skim ,, (sweetened).

Digestibility of Condensed Milk.—Condensed milks are more digestible than pure cow's milk, due to the fact that they do not seem to form curds in the stomach at all, or if they do, the curds are more flocculent than ordinary milk. It seems probable that during condensation casein undergoes certain chemical changes and hinders formation of clots.

As a rule condensed milks are of less nutritive value than pure milk, due to their containing less fat. Hence condensed skim milk should better be avoided, as well as the sweetened whole milk. For infants it is better to avoid any form of condensed milk. If however fresh milk be not available, unsweetened condensed whole milk should only be used.

Although infants fed on condensed milk may look fat, they are pale and flabby, and often suffer from rickets or a condition similar to scurvy.

PREPARATIONS OF MILK.

Curdled Milk, Sour Milk or Dahi.—This is fermented milk very largely used in this country. There are two kinds of *dahi*, one sugared and the other non-sugared, and the usual practice is to consume it within 36 hours of its preparation. This sour milk owes its virtue to the production of lactic acid, but the causative element is a streptothrix, with characters similar to *B. Bulgaris.* The importance of the organism lies in the fact that it kills all pathogenic non-sporing germs and also destroys all proteolytic gas-forming bacilli in the milk. Professor Kitasato has proved that 0·3 percent of lactic acid kills comma bacillus in 5 hours. The addition of sugar previous to curdling does not affect the amount of lactic acid, but masks the acidity and makes it palatable.

Butter-milk or Ghol.—This is milk left after butter is taken away by churning. Ghôl is generally prepared in India from sour milk or *dahi.* It is a sour-tasting fluid of varying consistency according to the amount of water present, with the casein of the milk existing in a finely coagulated state, *i. e.* in a more easily digestible form than when in ordinary curd. The lactose is in great part converted into lactic acid, and contains very little, if any, fat. It is very nutritious and its use in the form of a drink is an old established custom with the people of Bengal.

Curd and Whey.—Whey is the fluid left after casein is removed from milk. It may be prepared by some weak acid or by the addition of rennet. Whey contains all the original sugar, most of the mineral ingredients and about ·8 per cent of proteid. When milk is coagulated by rennet it gives an alkaline reaction and forms the so-called "sweet whey."

The curd of milk is commonly known as "chhana" or "khilat." Its use is practically limited to Bengal. From this curd, which contains chiefly casein and some milk globules entangled in it, a large number of delicacies are prepared by the addition of sugar, syrup, &c. The production of curd or *chhana* depends on the action of the products of a *bacillus* and not on the living bacillus itself. It is rich in proteid and contains certain amount of fat. It contains proteid 24·06, fat 2.5 and salts 1·1.

Koumiss and Kefir.—These are in reality preserved milk containing lactic and carbonic acids and a little alcohol. True koumiss, as prepared by the Tartars, is fermented mare's milk. Artificial koumiss may be brewed at home from cow's milk by the following process:

Pour fresh butter-milk (which remains after the butter has been separated by churning) 1 part, water 2 parts, cow's milk 8 parts into a loosely covered jar or bottle and keep it in a warm place, say near a fire, for 36 to 48 hours, with frequent brisk shaking. A slightly effervescing and a rather sharp tasting fluid results; the casein being partially digested by the fermentation of the sugar. Koumiss is an easily assimilable nutritious food and remedy.

Kefir is a fermented milk like koumiss, the ferment being a Caucasian mushroom. It can also be made at home by the addition of kefir ferment, which is a hard yellowish-brown granular body collected from the vessels from which true kefir is made, or by adding a fungus which contains yeast and *bacillus acidi lactici.* A sparkling beverage is obtained within 24 hours. It is usually prepared from cow's milk.

In koumiss and kefir the caseinogen is thrown down in a finely flocculent and easily digested form, and is also partly peptonised. Most of the sugar is converted into lactic acid, and a small amount of alcohol and a large proportion of CO_2 are generated. 3½ quarts (daily allowance) of koumiss yield 140 grms. of proteid, 80 of fat, and 140 of sugar with a combined fuel value of 1,918 calories.

Cheese.—This consists of coagulated casein and fat of milk modified by the growth in it of different micro-organisms, to the bye-products produced by which the different varieties of cheese owe their flavour.

Cheese is infiltrated with the fat it contains and is not so easily digested by delicate stomachs. Digestion however becomes more easy if it is eaten properly masticated. But the difficulty of digesting cheese is only restricted to the stomach, as it is very easily and completely digested in the intestines.

Cheese is a cheap form of animal food of high nutritive value and is a valuable substitute for meat. According to Hutchison beef contains less than half as much nourishment as the same weight of cheese. It deteriorates rapidly in the tropics, and is chiefly adulterated with starch.

Butter.—Butter is obtained by churning either the curdled milk or the cream, when the fat particles clot together, entangling in their meshes water, some casein and serum. Butter is used to a much less extent by the natives of this country than *ghee* or clarified butter. Butter contains casein, various fats, lactose, salts (phosphates), water and an aromatic principle. Butter fat contains 40 per cent of olein and is rich in those fatty acids (butyric, caproic and capric acids) which are soluble in water. An average sample of butter contains 7·5 per cent of water, 1·0 per cent of proteid, 90·5 per cent of fat, 1·0 per cent, of salt. The districts of Jessore and Midnapur in Bengal are the chief centres which export butter prepared from cow's milk, and those which export butter from buffalo's milk are Dinapur, Aligarh, Darjeeling, Ahmedabad, Surat, Bombay, Kampti, &c. The percentage of water in different samples of butter, as sold in Calcutta, rarely exceeds 16, except in Ghatal (Midnapur) butter which gives an average of 30 per cent. Butter may be preserved by the addition of salt or by keeping it in water.

Butter is most easily digested of all foods. As the butter fat approximates, in the proportion, to olein of the fat of human body, it is of great value as food. Absorption of butter in the intestines is complete.

Though adulteration of butter is not so universal as of milk or ghee, yet it is not uncommon. Water is the chief adulterant but admixture with low grade ghee, animal fat and curd are also met with. In England it is chiefly adulterated with *Margarine*, which is prepared by churning melted or clarified beef or mutton fat with skim milk.

GHEE.

Ghee is clarified butter and used chiefly in place of butter in India. It is prepared either from the milk of the cow or of the buffalo. Buffalo ghee is whiter in appearance while cow's ghee has a faint yellowish tinge and a pleasant sweet smell.

Ghee is made from milk which is first boiled and then curdled. In about six hours the curdled milk is churned after adding a little water, when the butter floats at the top. This is then collected, washed and boiled—the butter melts, casein and water falling to the bottom. The floating ghee is then finally strained and stored in earthenware vessels, or in tin cans or leather cases.

Ghee is generally used in the preparation of various kinds of food such as sweets, *puris*, &c. It is also taken along with rice, curries, dals, &c.

Buffalo ghee " contains more soluble volatile acids as determined by the Reichert Wollney process, corresponding generally to form 34 to 39 c.c. of deci-normal alkali for 5 grammes of ghee. In forty samples of purified ghee carefully prepared from pure buffalo milk in the Calcutta Municipal Laboratory for standardisation purposes, the minimum Reichert value, in terms of decinormal soda, was found by Dr. J. Dutta and Dr. S. B. Ghose to be 30·5, and the maximum 39·3, the average being 34·5 for 5 grammes of the ghee, while the minimum Reichert value for ghee from pure cow's milk was 22, the maximum 27, and the average 24, for 5 grammes." (Simpson).

The following standard for ghee has been adopted by Drs. Dutta and Ghose of Calcutta :—

	Cow.	Buffalo.
Specific gravity	911—912.	911—913.
Soluble volatile acids in terms of decinormal soda by Reichert Wollney method	24 c. c.	30·5 c. c.
Melting point	34°—35·5° C.	34 —36 C.
Oleo-refractometer at 45° C.	– 32—35	– 32—35
Butyro-refractometer at 40·5° C. ...	41—42·5	41—42·5

Taking an average of four years about 270,000 maunds (8 gallons equal to 1 md.) of ghee are annually imported to Calcutta, and about 100,000 mds. are consumed in the town and suburbs.

Ghee as sold in the market is almost wholly prepared from buffalo milk. Ghee prepared in winter is superior to that prepared during autumn. Nearly 70 per cent of ghee of the Calcutta market is adulterated. The principal adulterants are ground nut oil (*china badam*), animal fat, mohua oil, poppy seed oil, cocoanut oil, castor oil, &c. All these are hard of digestion. If adulterated with animal fat it generally remains in a solid state. Plantains, boiled potatoes and other vegetables, suet, brains of animals are said to have been found in solid ghee.

In cold weather good ghee should be clear, white and solid with a very faint agreeable odour. If dirty or bad smelling it should be condemned.

Presence of vegetable oils can be detected by the following test :—

Take one part of the suspected ghee and four parts of chloroform in a test tube and agitate by adding a few drops of phosphomolybdic acid ; on allowing the test tube to stand a green ring will be noticed at the junction of the two substances.

Animal fat may be detected by the following tests :—

1. Take equal parts of glacial acetic acid and the suspected ghee in a test tube and dip it in warm water, agitate frequently and note the temperature at which the ghee melts. If it melts at a temperature between 29°C. and 39°C. then it may be taken as a good sample. But if the melting temperature be higher than this then it indicates adulteration with animal fat. This is known as Valetine's test.

2. Shake well in a test tube dilute carbolic acid (9 parts of the acid with one of water) 2½ parts, with ghee one part. Allow it to stand, when the animal fat will rise to the top while the butter fat or ghee will be dissolved by the acid.

CHAPTER XI.

BEVERAGES AND CONDIMENTS.

Beverages.

Beverages are substances which by enabling food to be taken with pleasure and relish act as food accessories. They appear to stimulate digestion by acting on the digestive organs, either directly, or through the central nervous system.

Water is the universal beverage, and almost all other beverages contain water more or less. The utility of water in human economy has already been discussed. It must be stated here that absorption of water does not take place in the stomach at all, and the sooner it reaches the stomach it begins to flow out into the intestines, and the rapidity with which it passes through this organ makes it a very dangerous vehicle of infection. Therefore contaminated water is more dangerous as a carrier of disease than infected milk. Roughly, it takes about an hour for a pint of water to leave the stomach. Hot water excites the movements of the stomach and tends to open the pylorus. The practice of drinking water during or immediately after meals is not to be commended, as it interferes with digestion by diluting the gastric juice and causing bolting down of the bolus of food without proper mastication. It should better be taken an hour before meals. This causes the tissues to become saturated with water and thereby lessens the demand for water during meals. It washes the stomach out and by removing the food particles from the stomach prepares it for the reception of fresh food. There are again, increased salivary and gastric secrctions which help in the proper mastication, insalivation and thorough digestion of food. Some however hold that water taken during meals, hastens digestion by softening food and reducing them to a soft pulp.

Ærated and Mineral Waters.—Artificial ærated water was first prepared by Priestley by charging water with carbon dioxide gas at a high pressure. Mineral waters when derived from natural springs, besides containing some natural ingredients, are impregnated with CO_2 gas. Artifical mineral waters are prepared by dissolving in water salts of soda, lime and magnesium, commonly present in natural water, and then charging it with CO_2 gas.

Mineral or ærated waters have a sharp pleasant taste, and mineral water, of all other beverages, promotes the chemical process of digestion. The CO_2 gas by stimulating the movements of the stomach helps the mechanical process of digestion, and by lowering the sensibility of the nerves of the stomach acts as a gastric sedative. When added to milk, ærated water causes it to coagulate in small flakes, and when used with acid wines, neutralises the inhibitory action of the wine on the saliva. Ærated water is not always sterile; excepting perhaps the comma bacillus, many other organisms thrive in CO_2 gas; moreover, ærated water is often prepared from water not always above suspicion.

Besides the above, beverages commonly used may be divided into 9

A. Non-fermented drinks, and

B. Fermented drinks.

A. Non-fermented Drinks.

Tea.—A hot infusion of the leaves of various plants is used as a beverage in almost all parts of the world, but the most important and widely used of all is tea. This consists of the dried leaves of a shrub called *Cammellia thea* mostly cultivated in China, Japan, India (chiefly in Darjeeling and Assam) and Ceylon. There are various trade names under which tea is sold, and these different varieties are named after the different leaves from which they are produced. The leaves from the top of the shoot, *i.e.* the youngest ones, containing least fibres and abundant juice, are called in India *flowery* or *orange pekoe*, and form the best variety of tea.

The leaves from just below and larger than the above set are called *pekoe*, and those lower than that are *souchang*.

The leaves uncurl when placed in hot water and are oval or lanceolate with serrated margin, but the serrations do not reach up to the attachment of the stalk. The primary veins run out alternately from the mid-rib nearly to the border with looped venations. The apex is notched.

The chief difference between **green** and **black** tea depends upon the time of gathering the leaves and the mode of treatment. Black tea is fermented which renders the tannic acid less soluble. Green tea is prepared from the younger leaves which are roasted soon after gathering; an infusion of green tea therefore contains more tannin than black tea.

The *composition* of dry tea, according to Parkes, is thein 1·8 per cent, albumen 2·6 per cent, dextrin 9·7 per cent, cellulose 22 per cent, tannin 15 per cent, extractives 20 per cent, and ash 5·4 per cent. Thein is always found in combination with tannin but varies with different samples. Thein and caffeine are both dissolved in boiling water but the percentage of tannin is greater with India tea, if infused longer, than China tea. During infusion about 25 per cent of the weight of the leaves are dissolved out. Caffeine begins to dissolve out directly the infusion has started. Tannic acid dissolves slowly and the longer the tea is infused the more will it be dissolved.

Mode of Preparation.—The Chinese infuse tea for a few seconds only. By this most of the aromatic and stimulant effects are obtained without extracting any of the tannin. With the poor the common practice is to take tea not only very hot but very strong. The *proper method* of preparing tea should be by *infusion* and not by decoction, the infusion never to last for more than five minutes. If infused for a long time not only too much soluble matters are extracted but the tea loses much of its delicate aroma. The water should just come to the boil, as prolonged boiling makes it flat; it should neither be too soft nor hard, hard water interferes with the extraction of some of the ingredients of the leaves.

Adulteration of Tea.—Tea is often adulterated with leaves of willow, sloe, oak, &c. ; used leaves are sometimes mixed with fresh ones or coloured.

Coffee.—As ordinarily used it is the seed of *Caffea arabica.* It contains caffeine or thein and a volatile oil with an aromatic flavour. The seeds are first roasted to develop this oil and then ground to powder, when they are ready for use. The aromatic oil is very volatile and deteriorates rapidly on keeping, it should therefore be prepared fresh after roasting. During infusion about 25 per cent of the coffee is dissolved out. French coffee contains chicory and at times burnt sugar ; in fact coffee is largely adulterated with chicory. Dates, arrowroots, beans, maize and acorns are also used as adulterants.

Preparation of Coffee.—It should always be made strong and taken hot. About two ounces to the pint is a good proportion.

Cocoa.—It is not so widely used as tea or coffee and not so popular a beverage with the Indians. Cocoa is derived from the seeds of the fruits of the plant *Theobroma cacao.*

Cocoa as sold is known as 'soluble cocoa' or 'cocoa essence' ; but the term soluble cocoa is a misnomer, for cocoa is never soluble. In the form of powder it remains in suspension when mixed with water.

The chief active principle of cocoa is fat. The ordinary powder of the market contains 32 per cent of fat and 21 to 32 per cent of nitrogen in the form of proteid. The principal alkaloid is *theobromin* closely allied to caffeine.

Chocolate is a preparation from cocoa from which fat is not removed. It contains also white sugar, starch and some flavouring agents.

Actions and Uses of Tea, Coffee and Cocoa.

According to Professor Fraser, tea, coffee and cocoa retard peptic digestion owing to the presence of tannin and volatile oils. Addition of milk however partly diminishes this bad effect. Coffee is less liable to produce flatulence than tea, and therefore, should be preferred in cases of flatulent dyspepsia. Strong infusions irritate the mucous membrane especially when taken in an empty stomach and may either excite or keep up a condition of chronic gastric cattarh.

Taken in moderation tea gives a feeling of comfort and increases bodily and mental vigour. As a stimulant it differs from that of alcohol as it is not followed by depression. In the words of the poet it is a cup that cheers but not inebriates. As a beverage during exercise few things are so good as tea. In villages where water supply is not above suspicion it is always safe to have a cup of tea instead of water. Though the danger from infection through water is diminished by boiling, such water is not palatable, and addition of tea makes it an agreeable drink. Strong infusions taken in large quantities often cause constipation, though with some they act as laxatives.

Coffee causes stimulation of the nervous system and there is a feeling of exhiliration and diminition of the sense of fatigue. Caffeine lessens the feeling of hunger but does not prolong life in cases of starvation and increases tissue waste. Tea and coffee are in no sense food. Excess of coffee drinking causes nervous disturbances, palpitation and liability to attacks of neuralgia, hysteria and epilepsy. From the chemical composition of cocoa it appears to be a valuable food of much nutritive value ; but so little of it is taken at a time that its value as food is practically nil. An ordinary break-fast cup of cocoa would yield about 40 calories of energy. Chocolate however is of more value, and half a pint of milk and two ounces of chocolate yield about 400 calories.

Sherbets.—These are non-ærated sweetened drinks widely used in India as refreshing and cooling beverages especially in summer. They are ordinarily prepared by dissolving sugar, sugar candy, &c., in water and flavoured with either lemon juice or some other flavouring agents.

Cocoanut Water.—This is widely used in certain parts of India especially in Bengal as a refreshing drink, and useful in cases of acid dyspepsia especially when taken after meals. It has an acid reaction with a specific gravity of 1020 to 1030, and contains ·62 per cent of proteid, ·62 per cent of carbohydrates, and some salts. Where good water for drinking purposes is not available it is always safe to use cocoanut water.

B. Fermented Drinks.

Almost all fermented drinks contain a chemical substance of a powerful nature commonly known as *alcohol.* The distinctive character of alcoholic drinks depends on the particular kind of sugar or yeast used in their fermentation.

Alcoholic beverages for convenience of description may be grouped under the following heads.

I. Beer or malt liquor.
II. Spirits.
III. Wines.
IV. Country Spirit or Arrak
V. Toddy.

Alcohol consists of three elements, *viz.*, C, H and O and is represented by the formula C_2H_6O. It is generally prepared by the fermentation of sugar by which it is split up into alcohol and carbonic acid as follows:

$$C_6H_{12}O_6 = 2C_2H_6O + 2CO_2$$

Pure alcohol is lighter than water and mixes with it very readily. It is very inflammable and when mixed with water heat is evolved. When more water is added the less readily does it burn, and finally it does not burn at all. The term *proof spirit* owes its origin to this property of alcohol. Alcohol when weaker than proof spirit is known as *under proof*, and when stronger as *over proof*.

I. **Beer or Malt Liquor.**—Under this head are included beer or ale, porter or stout. Beer is the product of fermentation of malts and hops. Porter and stout are prepared almost in the same way as beer but the malt is first roasted like coffee, and the colour is due to caramalization of sugar.

The chief constituents of malt liquor are: alcohol, dextrine, sugar, vegetable acids and some soluble nitrogenous matter.

II. **Spirits.**—The chief difference between spirits and other alcoholic beverages is that the former are products of distillation and contain a certain percentage of alcohol. Roughly, spirits are compounds of alcohol and water but each kind has its characteristic flavour due to the fermentation of various bye-products during the process of preparation. Spirits are prepared by fermentation of various saccharine substances and any substance capable of yielding fermentable sugar may be utilised in their manufacture.

(*a*) *Whiskey.*—This is often described as a spirit obtained from fermented grain by distillation and containing from 48 to 56 per cent by volume of alcohol. It should be free from disagreeable odour and not less than two years old. There are two kinds of whiskey:—

(i) *Malt Whiskey* made in pot stills; the peculiar smell is derived from the peat smoke.

(ii) *Grain Whiskey.*—This is prepared from cereals—barely, rye or maize—to which a little malt is added to convert the starch into sugar. These are distilled in patent stills by which some of the bye-products of fermentation (fusel oil, &c.) are also separated. The excitement and tendency to fury is caused partly by the powerful intoxicating properties imparted to the spirits by its admixture with fusel oil, &c.

(*b*) *Brandy.*—This may be defined as a distilled wine and therefore varies in quality with the character of grapes used. When freshly distilled it is colourless and very strong. It improves with age due to the formation of volatile ether and aldehydes. Ordinarily it is not distilled from wines but prepared from "silent spirits" and coloured with burnt sugar and flavoured. When prepared from wines it is one of the purest and least injurious form of spirits and usually contains 45 to 55 per cent of alcohol.

(*c*) *Rum.*—It is prepared by fermentation of molasses but the best variety is obtained from direct fermentation of the juice of sugar cane. The colour is due to burnt sugar and improves in flavour by the development of ether. When kept in oak barrels it acquires an astringent property and is less irritating to the stomach. It contains from 50 to 60 per cent of alcohol.

(*d*) *Gin.*—This is obtained by fermentation of a mixture of rye and malt and flavoured with juniper berries, cardamoms and other aromatics. It contains 40 to 50 per cent of alcohol.

(*e*) *Liqueurs.*—These are spirits sweetened with cane sugar and flavoured with aromatic essences and contain about 33 to 55 per cent of alcohol.

III. **Wines.**—Wine is the result of fermentation of grape juice and in case of sparkling wine of a secondary fermentation of added sugar. The chief constituent of juice concerned in the fermentation are : sugar—which is a mixture of grape sugar or dextrose and fruit sugar or levulose—albuminous matter, tartaric and tannic acids. The presence of albuminous matter is important for the yeast lives on it and splits up sugar. Natural wines can never be stronger than 16 per cent of the volume, for the accumulated alcohol has a paralysing effect on the yeast. If the wine contains more alcohol, spirit must have been added, when it is called "fortified wine." Substances which influence the action of wines are :

(1) Ethylic alcohol and other higher alcohols.

(2) Acids—tartaric, tannic and the malic acids are the natural acids ; tartaric acid is present in the form of bitartrate of potash.

(3) Sugar—a natural wine contains about ½ per cent of sugar, fortified wines in which the fermentation has been checked contain as much as 2 per cent.

(4) Ethers are produced by the action of alcohol and acids, and two varieties, *viz.*, volatile and fixed ethers, are present.

The principal natural wines are :—

Claret containing 8 to 13 per cent of alcohol by volume.

Burgundy resembles claret. It contains higher percentage of alcohol and is richer in extractive matters.

Hocks are pale wines and have the strength of claret.

The fortified wines are :—

Sherry, contains about 15 to 22 per cent of alcohol by weight. With age sherry develops a large proportion of volatile ether more than any other alcoholic liquor.

Port wine contains 15 to 20 per cent of alcohol by weight.

Champagne is prepared from black grapes. Strictly speaking it should be a natural wine with 9 to 12 per cent of alcohol by weight.

IV. **Country Spirit or Arrak.**—These are prepared by fermentation of either rice, mohua (*Bassia latifolia*), molasses or *gur* (treacle). In case of molasses, gur or mohua the sugar is already formed and requires dilution with water. But in rice the starch has to be converted into sugar before fermentation. It contains about 40 per cent of pure alcohol by volume (30° under proof).

V. **Toddy.**—It is the fermented juice obtained from the spadix of fan palm, bastard date and cocoanut. When the fresh juice is exposed to the sun for about ten hours fermentation sets in, due to the conversion of sugar contained in the juice into alcohol; the fermentation is the result of the multiplication of the yeast-fungus contained in the liquid and the frothing is due to the production of carbon dioxide gas during fermentation. It contains about 5 per cent of alcohol and resembles beer in its effects. The yeast is widely used in the preparation of bread. Toddy is largely consumed by the lower classes of natives as a cheap intoxicating drink. Spirit may be distilled from toddy.

ACTIONS AND USES OF ALCOHOL.

Alcohol when taken into the stomach is freely absorbed, therefore it requires no digestion. It increases the secretion and stimulates the muscular activity of the stomach; but it has been shown by Sir W. Roberts that when alcohol is present in proportion of 10 per cent it causes a delay in the peptic digestion, in fact pancreatic digestion is more sensitive to the action of alcohol. But whatever might be the action of alcohol on the chemical part of digestion the balance of evidence is in favour of digestion, and that it actually shortens the period by about half an hour. But there is a concensus of opinion that alcohol when immoderately taken retards digestion and leads to degeneration of the alimentary tract. Liqueurs taken after a heavy meal gives a fillip to digestion, and often counteracts the bad effects of tea and coffee when taken at the same time.

Absorption of alcohol is very rapid, and is found to circulate into the blood within fifteen minutes after ingestion. It dilates the superficial blood vessels and the warm blood rushes freely through the skin giving a sensation of warmth. If freely indulged in, it causes a permanent dilatation of the vessels of the face especially of the nose. But while producing a temporary sensation of warmth there is in reality a reduction of the body temperature, as more heat is given off by radiation than could be produced by its own combustion.

Some important effects are also produced on the brain chiefly through circulation. When the cerebral vessels are dilated, intellectual activity may for the time being be so much increased that the person is enabled to perform much intellectual work. Thackeray, for instance, got some of his best thoughts "when driving home from drinking with his skin full of wine."

The question whether alcohol is a food has been much discussed, and the chief point is whether it can be regarded as a proteid sparer. Alcohol possesses the power of lessening nitrogenous waste, though inferior to carbohydrate and fat. It is chemically allied to sugar and undergoes combustion in the body; it, therefore, furnishes some energy to the organism and the chief claim of alcohol to the name of food is due to the fact that it will help to support life if given along with other food. But while undergoing combustion in the body it tends to lessen the combustion of other substances. Consequently for ordinary persons alcohol is a very unsuitable form of food; moreover, the actual amount of energy yielded by the permissible doses of alcohol is very small and promotes heat dissipation, a loss which must have to be counteracted by the heat resulting from its own oxidation.

Of the different forms of alcoholic drinks malt liquors containing, as they do, large quantities of carbohydrates are most nourishing. $1\frac{1}{5}$ oz. of bread contains as much carbohydrate as a pint of good ale. While a glass of milk yields about 184 calories, the same quantity of good beer will yield 168.

Does alcohol increase neuro-muscular activity? It has been proved that while alcohol may lead to a temporary increase of muscular activity it reduces the total output of work. The testimony of some of the experienced military experts is against the use of alcohol by soldiers in campaigns. Lord Kitchener, for instance, allowed his soldiers no spirits during the Soudan Campaign, and Lord Roberts had been equally firm in the matter of encouraging abstinence from alcohol.

By its use the function of the brain is augmented, but this increase of mental and physical power is followed by a stage of diminished mental activity. It is mostly because alcohol relaxes the control over emotion that its so-called stimulant action is due, but this is very soon succeeded by the narcotic effect. This narcotic action according to Brunton "lessens the closeness of the relationship between the organism and its environment, and the delicacy of its power of adjustment to external circumstances." Drunkenness caused by spirit is likely to be furious; that by wine, gay; and that by beer, stupid.

Admitting that a certain amount of alcohol is often taken with pleasure, and is also required under certain conditions, its use is at the best a habit, and whatever might be said in its favour alcohol can never be regarded as an absolute necessity for healthy persons. A stimulant, if at all necessary, should not only be of the lightest, purest and simplest kind, but should also suit the particular individual.

The question how much alcohol can be given to a person safely depends on a variety of circumstances. It is more harmful to those with sedentary habits than to those leading active and outdoor lives. Further, its effects also depend on the kind of beverage used. A glass of old and mature whisky is less injurious than the same quantity of raw spirit. It must be borne in mind while ordering alcoholic beverages that the effects produced are modified by various circumstances, such as (*a*) the amount of volatile ether they contain: this is of more importance than the actual alcoholic strength; (*b*) the degree of their dilution with water; (*c*) the age, toleration and habits as regards alcoholic drinks, of the person; (*d*) the amount of exercise taken by him; (*e*) the condition of the stomach, whether empty or full; and (*f*) the condition of his excretory organs, especially the kidneys.

For continuous use an ounce and a half of pure alcohol is all that can be utilized as a food in the human body daily. Roughly, 1½ ozs. of pure alcohol equals 3 ounces of whiskey or brandy which is equal to 1½ pegs, or is equivalent to 7 ozs. of sherry, 15 ounces of champagne, claret or white wine.

CONDIMENTS.

The use of certain substances along with food, which though properly speaking cannot be classed as such, but, which give relish to the food, is almost universal. These are food accessories and better known as *condiments.* Pawlow has shown that palatable and appetising food before reaching the stomach excites salivary, gastric and pancreatic secretions. But long before the experiments of Pawlow, men of all ages tried to render unpalatable food more appetising by the addition of savoury substances in the form of spices and condiments. Besides giving flavour and improving the appearance of the food and thereby exciting the secretion of the digestive juices, condiments relieve flatulent distension occuring from fermentation in the intestines. Substances especially useful for this purpose are those obtained from the N. O. *Labiatæ* and *Umbeliferæ.* The condiments commonly used are :—

Vinegar.—This is crude acetic acid and contains 3 to 4 per cent of glacial acetic acid. It has further the property of softening hard muscle fibres of meat, and cellulose of green vegetables. It is used with salads.

Mustard.—This is powdered seed of the black and white varieties of *Brassica nigra* and *alba.* The expressed oil (see page 138) obtained from the seeds is extensively used by the natives of India in preference to the powder. The powder from the black variety is often used for the preparation of curries, &c. Black pepper, cardamom, cloves, chillies, pod-pepper, corriander, anise, &c., are all used in the preparation of different articles of food to give colour, flavour or taste. Pulverised and mixed together they are sold as "curry powder." On account of the volatile oil present they prevent decomposition of food in the gastro-intestinal tract and expel flatus.

Turmeric (Curcuma longa).—This is also used as a condiment. Used in the form of a powder it acts as a carminative and improves the colour of cooked materials. The fishy smell is removed when fishes are cooked along with it.

Lemon.—The juice of fresh lemon is also much used, and acts as an antiscorbutic. Preserved in salt it is used as an appetiser. Green mangoes, green olives, tamarinds, &c., are all used as chutneys or tarts.

CHAPTER XII.

DISPOSAL OF REFUSE.

In every country, public health largely depends on the efficiency with which all refuse, specially excretal refuse (fæces and urine), and other house refuse (ashes, dust, slop-water, &c.,) are collected and removed. This may be effected by the following methods :—

I. **Scavenging.**—This includes collection and removal of ashes, dust, sweepings and other domestic and trade refuse, by manual or mechanical labour.

II. **Conservancy System.**—In this system slop water is got rid of by drains, and solid and liquid excreta are collected from privies or earth closets by either hand or mechanical means.

III. **Water-Carriage System.**—This consists of removal of human excreta along with liquid refuse of houses by a system of drains and sewers to some place outside the town limits.

I. SCAVENGING.

Town and house refuse consists principally of organic substances derived from articles of food, dust and a certain amount of mineral matter. But it varies with the season and habits of the people. Trade refuse consists of refuse from stables, cow-sheds, factories, shops, hotels, &c. Organic refuse has a tendency to undergo putrefactive changes when it gives off offensive smell and serves as a breeding place for flies, and provides food for rats, vermins, &c.; hence the necessity for its early removal. The refuse is received either in ashpits, or dustbins made of galvanised iron. Dustbins should be placed on a concreted and cemented surface, always at a fair distance from any dwelling house, and provided with a cover. The contents of the dustbins should be removed daily by specially constructed carts or wheel-barrows.

Disposal of Refuse.—After collection there are two methods of disposal of refuse, viz., *dumping* and *incineration.*

1. *Dumping.*—In this method the refuse is generally utilised in filling up insanitary tanks, lowlying lands (reclamation), hollows, &c., often outside human habitations. It usually creates a serious nuisance, and often gives off most noxious gases, and foul liquid draining from the heap may pollute the nearest water supply. Moreover, it breeds flies and harbours rats. (See made-soil, page 78).

2. *Incinèration.*—By far the best method of disposing of town refuse is to render it less offensive and harmless by subjecting it to a process of combustion ; with this fish offal and diseased carcasses may also be disposed of. This is generally carried out in a 'Destructor Furnace' or 'Incinerator' mixed with a small amount of coal to ensure thorough combustion, as ordinary street refuse of Indian towns is not always combustible. By this process the refuse is reduced to about one fourth of its original weight, and the organic matter is transformed into innocuous vapours, carbon dioxide and nitrogen. The residuum left after the combustion is a mass of hard material called 'clinkers' which are usually utilised for road making ; powdered and mixed with lime, they form cement.

Big towns should be divided into districts, and each one provided with a destructor furnace which may be placed in a central position to minimise the expense of transport. In most of the towns in India the practice is to throw house refuse on the street at all hours of the day. In Calcutta the refuse is removed by carts to the district unloading platforms, whence they are carried by waggons and utilised for reclaiming low-lying lands in the outskirts. In India, cow and buffalo dung is made up into thin flat cakes and dried in the sun to be used as fuel.

II. CONSERVANCY SYSTEM.

The primary object of this system is to get rid of excreta as soon as possible without allowing decomposition to set in.

In small municipal towns for want of sufficient funds it is not possible to lay down sewers for removal of excreta, neither can they be allowed to accumulate about the house. Hence removal of excreta by dry method is in vogue in the mofussil.

An adult European male living on a mixed diet passes about four ounces of solid and fifty fluid ounces of liquid excreta daily, while an Indian passes about eight ounces of solid. In India water, instead of paper, is used for cleansing purposes, and this ablution water together with the liquid excreta makes up about eighty ounces. The average daily amount of excreta to be dealt with in a given population can be estimated by multiplying eight ounces of solid and eighty of liquid by the number of persons. The important constituents of excreta are nitrogen, phosphates and potash. Fæcal matter, especially when mixed with urine, undergoes rapid decomposition and gives rise to foul gases chiefly organic vapours and ammonium sulphide. This generally happens in case of privies, cesspools, &c. It is a matter of practical importance that the excreta should be protected from rain and flood water, or else, not only the sewage is not efficiently removed, but the whole mass undergoes fermentation and creates a serious nuisance.

Latrines.—For practical purposes an arbitrary distinction is drawn between a *latrine* and a *privy*. A privy for public use is a latrine. The following points should be observed in the construction of privies :—

(1) The design should be such that all excreta and washings automatically find their way into some receptacle, so that no brushing will be necessary.

(2) The materials used should be non-absorbent to prevent pollution of the soil through soakage.

(3) Satisfactory arrangement for the reception of night-soil, and separation of liquid excreta, and for the cleansing of the same, should be made.

(4) The trap-door (for the sweeper) should be easily accessible, and the passage leading to it should be decent.

(5) Ventilation should be thorough and efficient, even when the doors are closed.

A **service privy** resembles the pail system in as much as the fæces is received into a movable receptacle of some form.

An **ideal latrine** or **privy** may be described under the following heads:—

(1) The superstructure or roof with the walls.
(2) The floor and the seat.
(3) The collecting chamber.

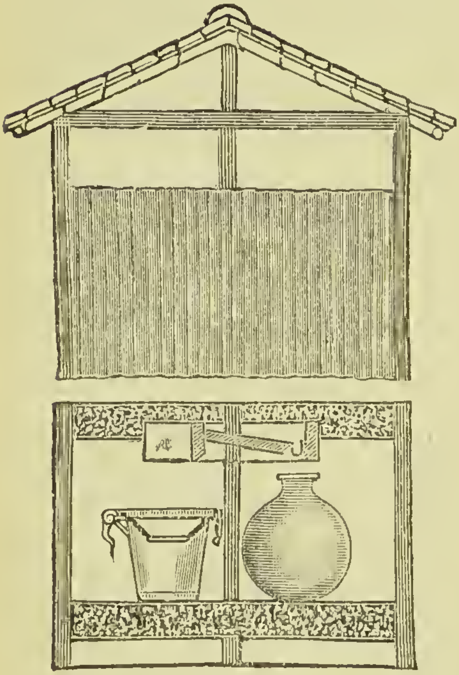

Fig. 7.

Private Latrine, showing the superstructure, the walls, the collecting chamber with anti-splash pail, and a vessel for collection of urine and water.

(1) *The Roof.*—It may be either terraced or sloping which may either be of corrugated iron, tiles or thatch. Of these corrugated iron is cheap, light and lasting.

The *walls* may be either of brick-work, corrugated iron or bamboo matting. They should be pigeon-holed for proper ventilation, but it is better that the roof should have an ample ridge ventilation; or an opening of about two feet may be left between the wall and the roof as shown in the figure. Large ventilating holes, each two feet square, may also serve the same purpose.

(2) *The Floor and the Seat.*—The *floor* should be made either of brick-work set in cement, slate, stone or iron, and should be sloped towards an opening or drain leading to a receptacle. The best material according to Major Clemesha is either vitrified brick, marble or granolithic cement. These are non-absorbent, and when properly laid make elegant and easily cleaned floor, and require practically no further attention.

The *Foot Rests* must be in the right position and not too wide apart or else the fæces will not fall into the receptacle below. A carefully designed seat will do away with the disadvantage of fouling the sides. The design given in the figure is best for those who ease themselves in a squatting posture.

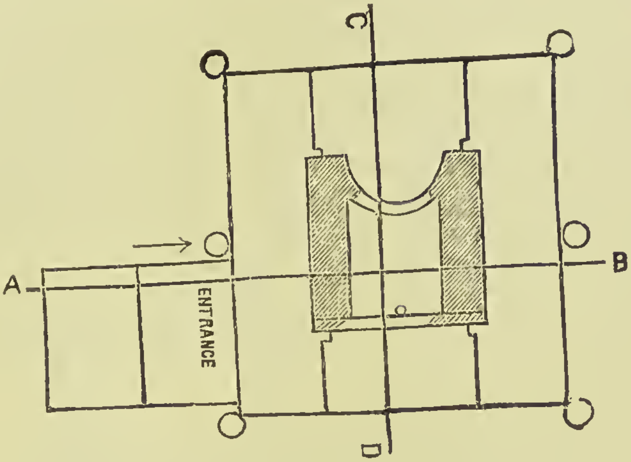

Fig. 8.

Section showing the seat arrangement of private latrines.

(3) *The Collecting Chamber* should always be of masonry work with the walls and floors cemented and corners rounded off for easy and thorough cleansing. The floor should be concreted and raised six inches above the level of the surrounding ground with a slope leading to an opening. The trap-door should be well-fitting and properly tarred.

The *Pail* or receptacle should be placed about six inches under the seat to prevent splashing. In some cases this distance is very great and may be 8 to 10 feet or even more. The best receptacle is tarred iron or wooden bucket or earthenware vessel (*gumla*). This should periodically be taken out, washed and tarred. To prevent splashing special anti-splash pails of galvanized iron with a removable conical cover, as shown in the figure, should be used.

The practice of using water for cleansing purposes in India necessitates a separate arrangement. The urine and washwater are then collected outside the privy in a tarred earthenware or iron vessel, or a small masonry well or cesspit (See fig. 7). It is important that all liquid should be separated from the solid excreta to minimise nuisance and the possibility of splashing.

Service privies should be at least six feet away from any dwelling, to permit a free circulation of air between the house and the privies. From a well or a tank they should be at a distance of at least fifty feet. The pail contents should as far as possible be kept dry by throwing ash, sand or dry powdered earth into the pail after each visit. This has the advantage of lessening the emanations of foul vapours. The contents of the pail as well as of the cesspit should be removed at least once a day.

Besides the above method the following systems are also in use :—

(1) The well system.
(2) The open air privy in field.
(3) The trench latrines.
(4) The commode system.

1. **The Well System.**—In this system there is no movable receptacle but the excreta is received in a hole or well, usually 6 to 20 feet deep, sunk in the ground. This system is most objectionable from a sanitary point of view, as not only foul gases are evolved but there is risk of pollution of water supply through soakage, especially after a rise in the level of the subsoil water. When these wells become full, they are covered with earth and new ones made. Such privies are still to be found in certain parts of Bengal.

2. **The Open Air Privy in the Field.**—In villages and rural areas where no proper arrangement for disposal of night-soil exists, people usually go to some open field or waste land to empty their bowels. Such places should be at a distance from any source of water supply.

3. **The Trench Latrines.**—These are made by digging trenches usually 12 inches deep and 18 inches wide. They should be properly screened and after a day or two filled up

with the excavated earth. These latrines are satisfactory as a temporary arrangement during fairs, &c.

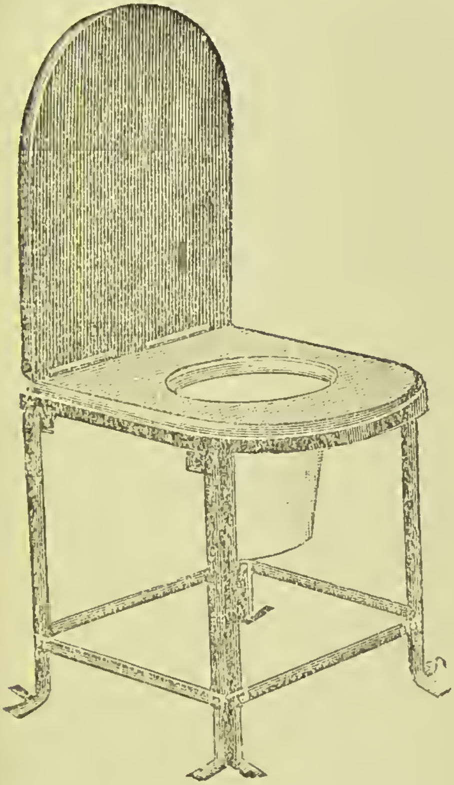

Fig. 9. *
The Commode.

4. **The Commode System.**—The use of commode is very popular with the Europeans in India. The arrangement is very simple and consists of a porcelain or enamelled pan fitted in a wooden or iron stand, the top of which forms the seat. If proper care is taken to keep the pan clean there could be no objection to its use.

PUBLIC LATRINES.

There are two types of public latrines,

(1) Fixed or permanent.

(2) Movable or temporary.

(1) **Fixed or Permanent Latrines.**—These should be constructed on good *pucca* plinths with a slope on one side, and no wood or any other absorbent material should enter into their construction. There should be a series of seats with separate receptacles for solid and liquid excreta. The approaches of the latrine should be properly made, and a sweeper retained for each such latrine, which should be cleaned at least twice a day.

A big public latrine with a series of seats is preferable to a smaller one. Such a latrine is very useful for general use, and may with advantage be placed in railway stations and other public places. The great point to be attended to in all public latrines is efficient ventilation and proper cleaning.

---

* Plate kindly lent by the Empire Engineering Co. Ld., Cawnpur.

The best material for their construction is corrugated iron.

(2) **Movable Latrines.**—These are of great use in segregation camps, in camps of exercise, *melas* (fairs) and all other places where latrines are required only temporarily. These are also convenient in cantonments or other situations where fixed latrines are not suitable. The latrine designed to meet the demand should be easy of transport, and when not in use, so compact that it can be packed away in a godown or shed. The receptacle for night-soil is simply placed on the ground with bricks for foot rest. The roof, sides and partitions are best made with corrugated iron sheetings. They are removed when the ground becomes foul and bad smelling when it should be dug up and left exposed to the sun and air for about a year. No masonry work should enter into their construction, and the site should always be high. The latrines should be removed once in a month during the rains, and every second month during the dry season.

Collection of Night-soil.

This is usually done by *methers* in tarred wooden buckets (pails), and carried either direct to the trenching ground, or are transferred into night-soil carts at the depots, and then taken to the trenching ground, for final disposal. In certain parts of Calcutta where hand removal system still exists, the night-soil is carried to depots and there emptied into the main sewer. Collection of night-soil should be done in the early hours of the morning, and if possible once again in the afternoon. Cesspit contents and urine may also be taken in night-soil carts for disposal.

Considering the fact that nuisance increases with the bulk of the population, and with the number of handlings, it is always better, whenever possible, to remove night-soil by substituting special receptacles in place of *gumlas* which can be carried bodily to the trenching ground either by a sling or on a specially constructed "Receptacle Cart." This will have the effect of minimising the nuisance by doing away with the ordinary night-soil carts and removing the filth direct from the latrines in absolutely air-tight sealed receptacles without being moved or stirred, and avoiding spillage or the spread of offensive odour.

Night-soil Carts.—These are usually made of steel with iron wheels. They have a capacity to hold 90 to 110 gallons, and are fitted with a double lid which can be sealed with a little earth. The body is pear-shaped and empties itself by revolving on the axles.

Night-soil depots should be located away from habitations and screened from public view.

DISPOSAL OF NIGHT-SOIL.

I. *Trenching Ground.* II. *Incineration.*

I. **A trenching ground** is a plot of land where the night-soil is deposited under the soil in shallow trenches. Strictly speaking trenching of night-soil is a biological process, but it is not customary to reckon it as such. The following is taken from the circular of the Sanitary Commissioner of Bengal for the proper management of trenching grounds :

"The objects of trenching are to dispose of night-soil with the least possible offence as regards smell and to prevent the breeding of flies which are great carriers of disease. It has been found by experience that deep trenching is most objectionable from a sanitary point of view as in this case the disintegration of night-soil is too long delayed and the ground does not become properly purified by cultivation......Shallow method of trenching which is by far the best should therefore be carried out properly......The trenches for this purpose should be dug one foot apart, should be either one or two feet in breadth and one foot deep ; night-soil to the depth of three inches only should be allowed to be put into them and should then be covered in with the excavated earth......For every twenty five gallons of sewage a trench two feet broad and one foot deep filled to the extent of three inches should be eight feet long, as $2' \times \frac{1}{4}' \times 8' = 4$ cubic feet or 25 gallons of sewage. The trenching ground should be divided into three plots so that every plot may be trenched once every three years. The remaining two plots must be kept under cultivation while the other is being used. Cultivation is a vital element in the success of a trenching ground as without this method of purification the ground becomes sewage-sick and unfit for re-trenching."

The following points should be observed in the selection of a trenching ground :—

(1) The site should be high, and the soil dry and of a light porous nature; clay soil being retentive is unsatisfactory, while light sandy loam is always good.

(2) It should always be at the outskirts of a town, and at a distance of about 600 yards from a dwelling place.

(3) A row of trees should be planted to separate the ground from the town, which will also prevent infective dust from being blown about.

(4) It should always be at a distance from the sources of water supply.

(5) It should be provided either with a well, or tank, for washing the buckets and carts, and irrigating the ground under cultivation.

(6) There should be good roads within the ground.

(7) Arrangements should be made for draining off rain water to low lying cultivated lands.

II. **Incineration of Night-soil.**—This method of disposal by completely burning up night-soil is being greatly advocated in India. If properly carried out in a well designed furnace destructor it will be found to be very sanitary; the possibility of contaminating the water supply or the danger of polluting the air by smoke or vapour will be reduced to a minimum. For the proper working of the incinerator the following points should be observed :

(1) *Thorough Supervision.*—Unless a strict eye is kept, the sweepers will never mix the night-soil with the inflammable material in proper proportion if left to themselves, and consequently the mixture will be either too wet or too much in bulk to burn.

(2) There should be an inexhaustible supply of inflammable material. The best material for this purpose is a mixture of sawdust and wood shavings ; coal dust mixed with street sweepings may also be used.

(3) The destructor must be properly designed.

Disadvantages of the Hand Removal System :—

(1) From a financial point of view it is not economical as it necessitates a large number of sweepers, carts, bullocks, &c.

(2) Its success depends absolutely on the way in which the work is carried out. The sweepers are very difficult to manage, and a badly-worked system is a source of great danger and nuisance.

(3) The wear and tear of night-soil carts, pails, &c., are very great.

(4) There are dangers of contamination of air and water, and spread of infection through flies.

(5) It is difficult to manage in towns having a large population.

(6) If suitable soil is not available, or if the trenching ground is not properly managed, the place breeds flies and becomes a source of danger to public health.

(7) The transfer of night-soil from pails to buckets, and from buckets to carts, creates great nuisance.

III. WATER-CARRIAGE SYSTEM.

Disposal of Slop Water.—The conservancy system does not provide for the removal of domestic or other waste-water, and to carry this out efficiently in towns and villages is a very difficult problem, for these are no less impure than ordinary sewage of water-closet towns. A system of drains, therefore, for the removal of such water becomes necessary. The slop water from isolated village houses is usually conveyed by *kutcha* drains, which are merely shallow open trenches or literally elongated cesspools, to the nearest tank, ditch, garden or open land. The consequences that may follow such a practice are obvious; they form a suitable breeding place for mosquitoes, flies, &c., pollute the neighbouring water supply after absorption, and during rains form dirty, fermenting and offensive puddles. It is not uncommon also to find tanks and wells close to or adjoining such drains.

It is generally found that weeds and other small plants grown in these *kutcha* drains materially impede free flow of their contents. Arrangements should, therefore, be made to remove these periodically and to maintain the level of these *kutcha* drains. But by far the best method is to have the drains either made *pucca* or constructed with some non-absorbent material, such as "Channelled Ranigunge Pipe," to prevent soakage. It is also necessary that there should be proper slope to carry the sewage rapidly. Sewage can be best disposed of by irrigation over agricultural lands or open fields, while the slop water of individual houses may be collected in suitable vessels or pits, and then removed to some cultivated land for final disposal. The sewage of the non-water closeted town of Manicktala, having a population of about 55,000, is discharged into the nearest salt water lake.

SEWAGE AND REMOVAL OF SEWAGE.

Waste water consisting of liquid and solid human excreta together with liquid refuse from cowsheds, stables, houses, factories, &c., is known by the term **sewage**. Waste water from houses unmixed with solid excreta is often known as **sullage.**

Removal of Sewage.—There are two principal methods of removal of sewage, *viz.*,

I. Conservancy system or dry method.—This has already been discussed.

II. **Water-Carriage System.**—In this system the solid together with the liquid refuse is carried from the immediate neighbourhood of habitation by a flush of water. Owing to the initial expense incurred in its outlay and also for the abundance of water supply that it demands this water-carriage system cannot be introduced everywhere. It appears to be cheaper in the long run, and is perhaps the cleanest, quickest

Specimen.
With HILTON & Co's.
Compliments.

and most sanitary method of removing night-soil. For these considerations the water-carriage system is indispensible in big towns.

House Drainage.

A complete system of house drainage consists of—

A. Water-closet.
B. Soil pipe.
C. House drain.
D. Traps.

A. **Water-closet.**—A water-closet is a sanitary installation for the reception of human excrement, and having connexion with a sewer by a pipe, it removes the excrement, when deposited, through the agency of water. It should be in a detached portion of the house, and at least two of its sides open to the outside air. When a closet is required for each storey the apartments should form a separate tower and connected to the main building by over-head bridges. The essential features of a good water-closet are that the basin should be of some non-absorbent and indestructible material, that the excrement shall fall without any external agency into the proper portion of the closet, and that the flushing should be of sufficient force to wash the basin clean and remove all traces of excreta.

A water-closet consists of the following parts :—

(1) The closet proper, consisting of the basin and a trap, and
(2) The flushing apparatus.

1. **The Closet Proper.**—There are several varieties of water-closets of which the following are the chief ones :—

(*a*) Pan closet.
(*b*) Valve closet.
(*c*) Long hopper closet.
(*d*) Wash-out closet.
(*e*) Short hopper or wash-down closet.

(*a*) *The Pan Closet.*—"It consists of a china basin, shaped like an inverted cone, with its outlet guarded by a movable metal pan which retains water in the basin." On raising a handle the pan falls back into a cast iron receptacle called the "container" into which the excreta fall. The bottom of the container is connected by a short pipe to a U trap (D placed sideways) made of lead to prevent the escape of foul air from the soilpipe. This variety of closet is not used nowadays, as it produces great nuisance. A certain amount of filth always remains behind in the trap and the container, and gives off foul gases; when old the metal pan corrodes and becomes leaky.

(*b*) *The Valve Closet.*—It consists of a stoneware basin with an opening below having a diameter of about three inches, closed by a water-tight and movable valve fixed by a hinge. The valve opens out on raising the handle and is received into a metal box, the lower part of which is connected with a syphon trap leading to the soil pipe. The closet should be flushed immediately after each visit with plenty of water (2 to 3 gallons) from a cistern, and arrangements made for an after-flush, *i.e.* for a supply of water into the basin after the handle is released. In case of excessive after-flush the basin may overflow. To prevent this an overflow pipe is attached almost at the top of the basin and is carried down into the valve-box with a syphon bent, which by holding water prevents the escape of foul gas.

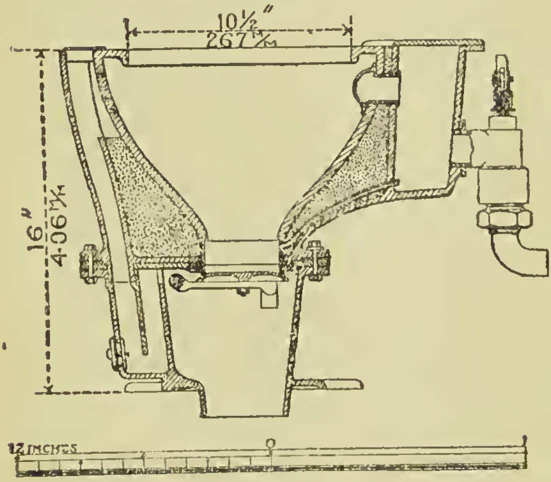

Fig. 19.*

Valve-closet.

---

* Plate kindly lent by Messrs. Shanks & Co., Barhead.

The advantage of this variety of water-closet is that it is noiseless, but the valve may leak in time, thus allowing water in the basin to escape, and foul air to enter into the closet apartment.

(c) *The Long Hopper Closet.*—This has no valve and the pan is deep and conical. The solid excreta often adhere to the sides, and therefore, a great force of water is required to thoroughly flush it.

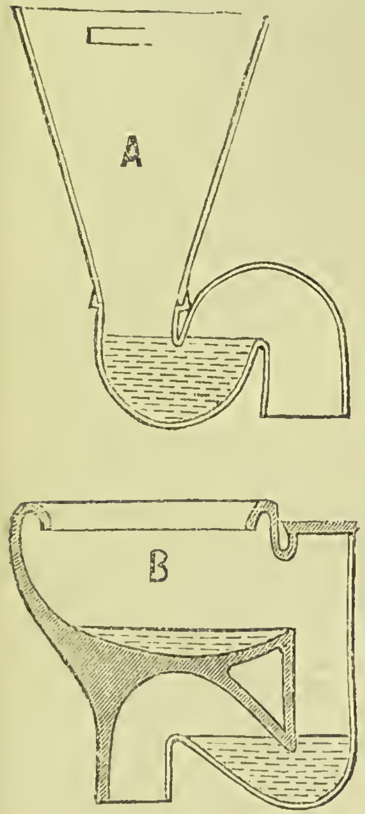

Fig. 11.
A. Long Hopper Closet.
B. Wash-out Cleset.

The *syphonic closet* is an improvement of this variety, as it retains a certain amount water in the pan for the reception of excreta. Besides, there is a syphon trap with a long ascending arm and the water contained in this trap is on a lower level than that in the pan. The contents of the pan are, therefore, subjected to a force of *vis a tergo* by the flush and a *vis a fronte* by the temporarily induced syphonage in the trap. With all this it appears to be unsatisfactory, as the foul water often regurgitates into the basin.

(d) *The Wash-out Closet.*—In this certain amount of water is retained in the pan by a ridge. The excreta will have to be flushed out over this ridge, and therefore a powerful flush is required for this purpose. This closet is not without defects, for, foul matters are often left behind and the water in the pan is not always enough to cover them.

(e) *The Wash-down or Short Hopper Closet.*—This is by far the best and extensively used. It consists of a short inverted cone the back of which is almost vertical so that the excreta may fall directly on the water in the trap without fouling the sides; with a rim flush it can be easily kept clean.

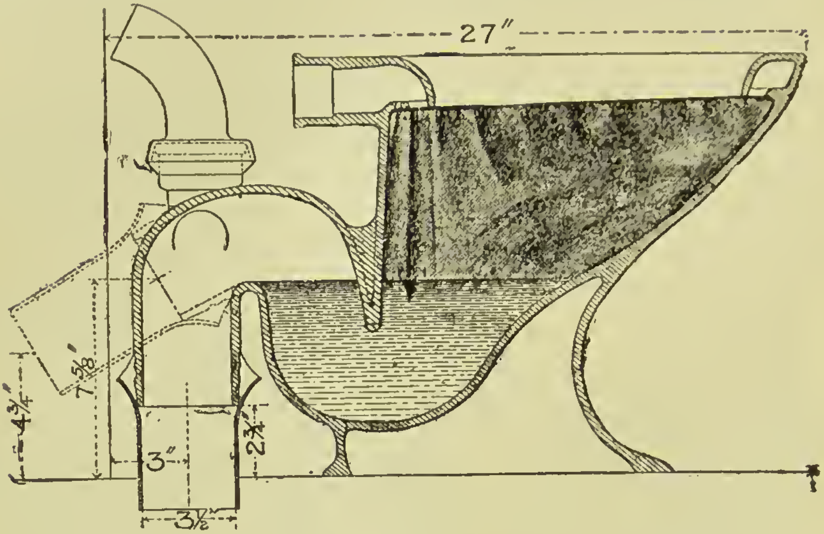

Fig. 12.*

Wash-down Closet with rim flush, showing P and S traps.

2. **The Flushing Apparatus.**—It is important that the water-closet should be flushed immediately after use; and provision should, therefore, be made for the storage and discharge of water. Water is stored in tanks or cisterns, which should be separate for each closet, connected with a main tank placed on the top of the house. The cisterns are usually made of galvanised iron, and should be placed about 4 or 5 feet above the basin and the water delivered by pipes of $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in diameter. The water is discharged either automatically, or by pedal action, or by a pull of the chain which puts the syphon of the cistern in action. About two to three gallons of water are necessary for each flush. It is not uncommon to find bath-room water conveyed to the closet for flushing purposes.

Trough Closets.—These are latrines suited for places like jails, hospitals, schools, &c. In these closets a long metal or earthenware trough is placed on an inclined plane under the seats of the closets placed side by side, for the reception of the excreta. The trough retains a certain amount of water by means of a weir at its lower end, and the excreta are expelled by a volume of water, discharged either by an automatic flush, or by an attendant, and carried away through a trap placed at the end of the trough. The advantages are : (1) one apparatus serves for the use of several persons at one and the same time ; (2) it is cheaper, and hardly ever gets out of order.

---

* Plate kindly lent by Messrs. Shanks & Co.

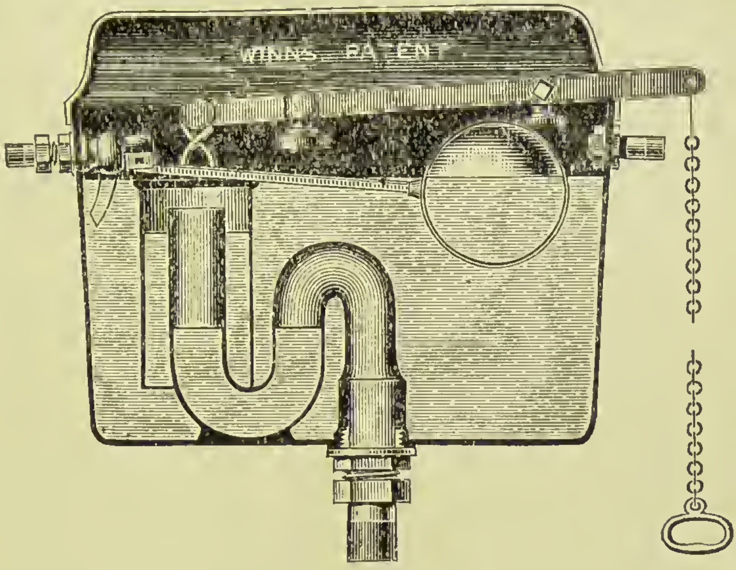

Fig. 13.
Syphon Flushing Cistern.

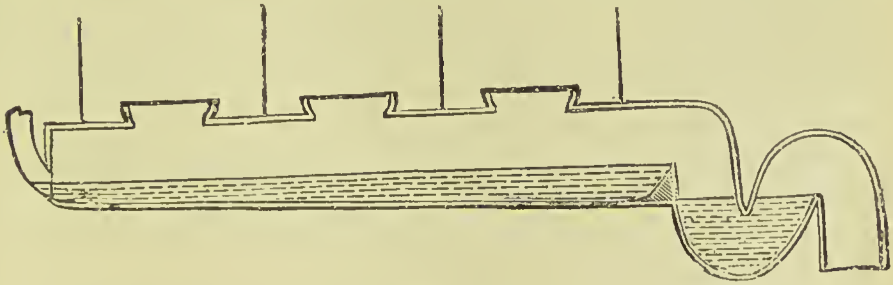

Fig. 14.
Trough Water-Closet.

B. **Soil Pipes.**—These are circular pipes connecting the water closet with the drain. They should be either of cast iron, or drawn or milled lead, about 8 pounds to the square foot, and laid as straight as possible. They should be exposed right through for ready inspection, and connected with the closet immediately beyond the syphon bend or trap, and carried directly outside the house-wall. They should have an internal diameter of four inches, and be carried clear of windows, 6 to 8 feet above the roof, for the escape of foul gas. The end may either be left open or covered with a wire-gauze dome. Whenever possible these pipes should be fixed on the shady side of the house to prevent the joints being damaged by the tropical sun. To prevent oxidation and rusting iron soil pipes should be coated either with a vitreous glaze or magnetic oxide of iron (Barff's process). The soil pipes of the Presidency General Hospital, Calcutta, are lined with glass.

The ventilation of soil-pipes is necessary, for it not only prevents admission of foul gases but also counteracts the syphonage by suction, which, during the transmission of the contents of one of the upper closets down the soil pipe, causes the water in the trap of one of the lower closets to be drawn off. The ventilation and consequently the anti-syphonic action is ensured by means of a pipe 2 to 2½ inches in diameter fixed a few inches beyond the trap.

The joints in the case of lead pipes should be "wiped," and in the case of iron ones caulked with lead. The connexion between the soil pipe with the closet pan, *i.e.*, between an earthenware and a metal, is best secured by "Doulton's ceramic joint," while that of the soil pipe with the drain by means of a "thimble" or a brass or copper tube about a foot long soldered to the lower end of the soil pipe, while the rim of thimble rests in the socket of the drain pipe and the intervening space filled with Portland cement.

C. **House Drain.**—A house drain is an under-ground pipe for carrying away discharge from water-closets (received through pipes) and waste water from house or compound as soon as possible to the sewer. It is usually constructed of some impermeable material such as glazed stone-ware or iron pipes. It should be laid without any angles or bends on a smooth inclined plane to facilitate easy transit of its contents; and if a bend is at all necessary it should be by special curved pipes. A branched drain should join the main one in an acute angle to lessen obstruction to the flow. It is not always possible in a large building to lay down drains in an uniformly straight line, and in these cases it is desirable to have manhole chambers for inspection at every change of direction and to continue the drain through the floor of the chamber by means of half channelled pipes. The joints should be made both air and water tight. For ordinary houses, the drain should usually be about 6 inches in diameter, but in big buildings, such as hospitals, hotels, &c., it should be about 9 inches with a fall of about 1 in 50 and a flow of 2½ feet per second. It should be remembered that the smaller the drain the better is the flushing and removal of deposit, but in every case it must be large enough to prevent blocking. For all these purposes glazed earthenware pipes are satisfactory and should be laid on a smooth bed of concrete 6 inches deep. When carried under the basement of the house there should be six inches of cement concrete all round, and where the collar of the pipe rests, the concrete should be hollowed out and the joints made both air and water tight.

Manhole or Inspection Chamber.—This is a square masonry tank lined with cement and provided with an air-tight iron cover, ventilation being carried on by a 6 inch pipe. The manhole end of this pipe is opposite the entrance of the drain, while the other end, which is protected by an iron-grating and provided with a mica flap valve, is carried a few feet above the ground level and opens into the outside air. The valve while admitting fresh air prevents reflux of foul gases. The sewage is conveyed through the manhole by glazed half-channelled pipe which discharges itself into a trap. The floor of the manhole should form an angle of 30° on either side of the channel. The branch drains which are also made of glazed channel pipes curved to the proper degree empty themselves into the main channel. This intercepting trap should be fitted with a raking arm or cleansing eye which opens into the drain leading to the sewer. This arm allows the removal of obstruction from the drain between the sewer and the trap. Whenever possible all manholes should be situated in open spaces or yards and not actually within the building.

Although it is generally held that sewer air is not more harmful than drain air, yet a disconnexion of the drain of the building from the public sewer is necessary. This is generally done by having a syphon trap interposed between the house drain and the sewer. The following points, recommended by Parkes and Kenwood, should be observed in selecting such a trap :—

(1) Where the drain is a 6-inch or a 9-inch pipe, the syphon should be a size smaller than the drain ;

(2) there should be a fall of 2 inches or more from the level of the discharging end of the house drain to the surface of the trapping water ;

(3) the syphon should provide an adequate seal of two or three inches of water ;

(4) the inlet to the syphon should be nearly vertical, whilst the outlet rises at be angle of not more than 45°.

D. **Traps.**—A trap is an arrangement which acts as a barrier to the entrance of sewer air into a house effected by what is called a *water-seal*. A good trap will completely disconnect the air of one pipe from that of another. A

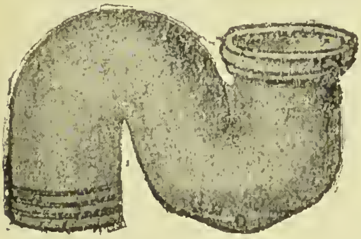

Fig. 15.*

S trap.

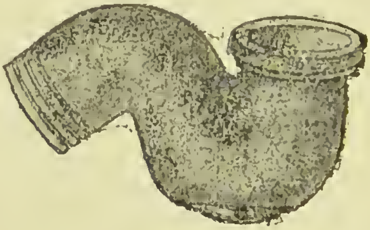

Fig. 16.*

P trap.

---

* Plates kindly lent by Messrs. Shanks & Co.

trap in its simplest form is a bent pipe which holds up water and prevents air or gas from passing through.

The *water-seal* of a trap is the distance between the level of the water in the trap and the lowest point of its concave upper surface when the trap is in proper position. This seal should be at least one inch in a good trap.

A trap should be self-cleansing with every flush of water, and have no angles, corners, cracks or projections inside, which might impede the onward flow of any solid matter. The following are its usual positions:

(1) Under the pan or basin of each water-closet.

(2) Near the junction of the house drain with the sewer.

(3) In the open air at the level of the ground to receive slop water from bath, lavatories, &c.

Varieties of Traps.—There are many varieties of traps but the following are the principal ones:

(1) *Syphon Trap.*—It is simply a bent tube, the bend being full of water, which should stand at least $\frac{3}{4}$ inch above the top of the curve. It is the best form of trap and maintains a syphonic action as it always keeps a constant level of water. When two syphon traps follow each other one will suck the other dry. This is prevented by having an air opening between them.

(2) *Flap Trap.*—It is a hinged valve permitting water to flow in one direction. It is inefficient and allows sewer air to enter the house.

(3) *Mid-feather Trap.*—This consists of a round or rectangular box provided with an inlet tube on one side and an outlet tube on the same level at the other. Water stands up to the lower margin of each pipe with a partition between, which touches the water. This is not self-cleansing.

(4) *Bell Trap.*—This is a modification of the above but is equally unsatisfactory as the water-seal is broken when bell portion is removed.

(5) *Gully Trap.*—This is placed in yards, especially where rain water and waste water pipes open. It should be placed at a distance of about a foot and a half from any wall, and the surface opening should be as small as possible and protected by a grating to prevent evaporation. Such traps, though simple and efficient, require occasional cleansing, as solid particles falling to the bottom may eventually block the opening for outlet.

Besides the above there are many other varieties of traps, but none are efficient.

THE TESTING OF DRAINS, SOIL PIPES, &C.

Testing of drains, &c., is always necessary, and is employed not only for new sanitary installations and during the progress of the work to find out if it has been properly constructed, but also in cases of old drains to ascertain whether they are still in good order. The following tests are commonly used :—

(1) *Hydraulic or Water Test.*—This is of value in whatever position the pipe is placed and is especially used in new drainage work. To carry it out plug the lower end of the drain by a suitable water tight cover and fill it gradually with water. If the level of the water remains stationary after stopping the flow, the drain is sound. But should the water level fall, or

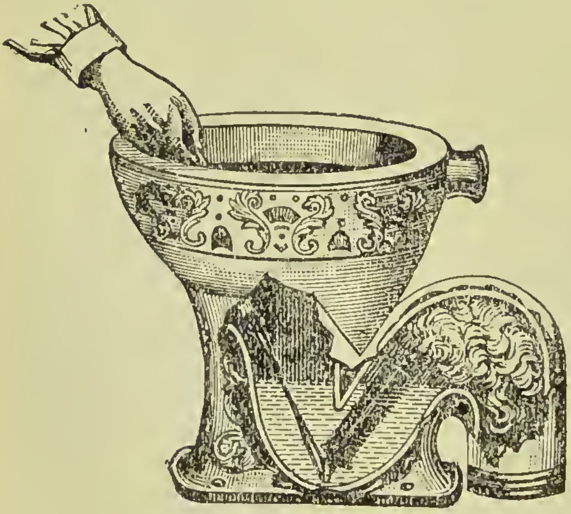

Fig 17.*

Showing the application of smoke test.

---

* Plate kindly lent by John Jones, Ld., London.

if the drain does not fill at all, it indicates defect at some point and the joints should be carefully examined.

(2) *The Smoke Test.*—This is usually done by burning either brown paper or by means of a smoke rocket. This test may be applied either in vertical soil pipes, drain ventilating pipes or manhole chambers. If there be any leakage or faulty joints, the smoke will issue out and expose the defects. The smoke may also be pumped into the pipes by bellows.

(3) *Chemical Test.*—This test can only be applied in case of vertical soil pipes or drain ventilating pipes and not in under ground drains. To carry it out pour two or three buckets of hot water with a fluid drachm of oil of peppermint down the highest water closet, or down the pipe from the highest available point. If on examination its peculiar smell is perceived the leakage will be discovered. In case of the smell coming out from any of the lower closets it points to defects in traps and soil pipes.

SEWERS.

Sewers are underground conduits designed for the reception and removal of both rain water and sewage by gravitation. This system of sewage removal is known as the "combined system." Two sets of channels are sometimes provided—one for carrying the rain and waste water, while the other—a smaller one—for sewage alone. This method is called the "separate system." Those carrying the waste water take the shortest route to the nearest watercourse or river where they empty themselves, the other set conveys for final disposal by one of the methods to be presently described.

The *advantages* claimed for the separate system are :

(1) The sewers required are of smaller dimensions and so easily flushed, consequently there is less deposit.

(2) The sewage is uniform in quality and smaller in quantity.

(3) Purification and utilization are effected with less difficulty.

(4) In a known population estimation of the total bulk of sewage can be done from the allotment of water per head.

(5) More cheaper than the combined system.

The disadvantages are :—

(1) Two sets of pipes are required for every house and so a wrong connexion may be established by mistake.

(2) The rain and storm water washes away much that would contaminate a stream.

(3) The flushing effect of storm water on the sewage is lost.

These objections are, however, not of much consequence, and the adoption of either plan depends upon local circumstances. But whatever system is adopted, two objects should be aimed at, *viz.* (1) removal of sewage by means of impervious pipes, and (2) drainage of subsoil water along the route.

Sewers up to eighteen inches in diameter are circular, and made of either iron or glazed stoneware pipes jointed together with cement. When of larger dimensions they should be of brickwork and cement. Iron pipes should be coated with Angus Smith solution to prevent corrosion. The best sewer in cases where the volume of sewage undergoes great fluctuation is ovoid or egg-shaped with the smaller end downwards. This gives a greater depth of sewage and less contact with the inside walls, consequently there is less friction. Besides, it is much stronger and offers greater resistance to outside pressure.

Earthenware pipes are best laid on a bed of concrete and the joints thoroughly cemented, and the inside should be absolutely smooth. No public sewer should have a diameter of less than nine inches.

Sewers should be self cleansing and constructed with sufficient gradient. The size should be proportionate to the volume of sewage they have to convey. To prevent deposition in pipes of twelve to twenty-four inches in diameter the velocity should be $2\frac{1}{2}$ feet per second, and in sewers of larger dimensions two feet per second. A less gradient is necessary for larger sewers to produce the same velocity as in smaller ones. The fall should be equable, and all sudden changes in the level should be avoided; a sewer of ten feet in diameter should have a fall of two feet per mile. To calculate the velocity of the flow through sewers the following formula is used :—

$$V=55\sqrt{D \times 2F}$$

V=Velocity of flow in feet per minute;

D=Hydraulic mean depth;

F=Fall in feet per mile.

If A = the sectional area of current of fluid, $V \times A$ = discharge in cubic feet per minute. The *hydraulic mean depth* is the sectional area of the current of fluid divided by the wetted perimeter, *i.e.* the portion of the circumference of the sewer in contact with flowing fluid; in circular sewers running full or half full, it is one-fourth the diameter.

All sewers must be laid with as few bends as possible and the junctions made at acute angles to allow the sewage to enter in the direction of the flow. Curves, if there be any, should be gradual and the radius of the curve being not less than ten times the cross sectional diameter of the sewer; thus if a sewer be five feet in diameter the curve should never be less than 50 feet.

Inspection, Cleansing and Ventilation of Sewers.

In the sewerage system, it is necessary to provide adequate means for periodical examination, cleaning and removal of deposit. To meet these ends manholes are to be provided for. These are shafts sunk from the surface of the ground through which a man can descend into the sewer. Branch sewers are made to join the main sewer in these manhole chambers. At these points of junctions flushing gates may conveniently be fixed in brick sewers. "Flushing gates are sluices made to fit the whole or part of the sectional area of a sewer. When in position they dam back the sewage in the sewer above and on being raised or liberated the sewage so stored rushes forwards and effectually flushes the sewer below. Self-acting gates are often used for this purpose." (Parkes and Kenwood.) In some parts of Calcutta the sewers are flushed daily by automatic flushing stations. The main sewers are regularly flushed from the Hughly once in a fortnight and cleared of deposit once in six months.

Ventilation of Sewers.—In every sewer where the sewage is well diluted, the flow rapid and flushing efficient, depositation of sediment does not occur, and the air does not become very much foul. But owing to the constant variations of the flow of sewage some deposit forms on the sides, which not only undergoes putrefaction but gives off putrefactive ferments to the sewage flowing by. The tendency to such deposits is less in pipe sewers than in brick ones. It should be remembered that the gases evolved by decomposing sewage are combustible, and one should therefore be careful in carrying an unprotected light into a newly opened manhole, old drain or cesspool. Ventilation of sewers is, therefore, necessary to dilute such gases.

The simplest way for ventilating sewers is to have a shaft from the crown of the sewer to the middle of the surface of the street above, where it is covered by an iron grid having a tray or dirt-box below to catch stones, &c. These openings should be at a distance of about 100 yards. Some of them act as inlets while others as outlets. The air which escapes through these ventilators is rapidly diluted by fresh air and so rendered inoffensive.

Another method is to fix long iron shafts at suitable distances along the length of the sewers. These are carried sufficiently high into the air well above the top of the neighbouring houses for the exit of sewage air or gas into the atmosphere. Street gullies must be efficiently trapped to prevent mud and sand from entering the sewer and the escape of sewer air.

Disadvantages of Sewers.—(1) Sewers being closed conduits may cause the effluvia to enter into houses; but if they are properly constructed, flushed, trapped and ventilated this may be prevented.

(2) Any leakage, &c., may contaminate the nearest water supply. A sewer may leak for various reasons: from cracked joints or pipes, sinking of foundations, imperfect joining or laying, and by the penetration of roots through faulty joints and cracks.

Effects of Sewer gas on Health.—See page 44.

Outfall Sewers.—In every case it must be large and free so that no obstruction to the discharge of sewage may occur. The outfall must be below the level of the water, independent of the tide, and the opening guarded by a valve to prevent the entrance of water. Where sewage is tide-locked for several hours it should be conducted into specially constructed tanks or reservoirs and then discharged into the river or sea at suitable states of the tide. Sometimes sewage may have to be carried across a river or a valley by bridging, but this is not always practicable when the outfall sewer lies on a lower level. Under such circumstances it should be carried across by the help of an inverted syphon laid in the valley or in the bed of the river. Should the velocity of the current be not sufficient, accumulation and consequent blocking of the syphon with solid matter might take place; therefore, steps must be taken for straining of the sewage and occasional flushing of the syphon.

Pneumatic System of Sewage Removal.—In case of lowlying areas, where removal of sewage by gravitation scheme cannot be efficiently carried out for want of proper gradient, or where tank sewers are productive of nuisance, recourse have to be made either to some system of periodical pumping to raise the sewage to a higher level or to one of the following systems :—

(1) *The Shone System.*—In this system the transmission of the sewage is effected by means of compressed air. This is conveyed from a central station to *ejectors* or cylindrical reservoirs placed for the reception of sewage under the ground at different parts of the town. When the reservoirs become full a valve opens and admits compressed air by means of a float acting on a counterpoised lever. This propels the sewage forcibly either into a sewer at a higher level or directly into the outfall. The regurgitation of the sewage is prevented by a ball valve in the pipe sewer, and as the ejectors empty themselves the sinking of the float shuts up the valve of the compressed air tube and allows a fresh quantity of air to enter. On flat surface where a suitable fall cannot be secured this system gives a proper gradient to the sewers and acts admirably.

(2) *Liernur's Pneumatic System.*—In this system there are two sets of pipes; the one smaller in diameter for the removal of waste water, and the other larger (5 inches) in diameter for the removal of sewage proper. The former is discharged into a river or stream, while the latter empties into small closed chambers or tanks placed at different parts of the town under the streets. The propulsion of sewage is effected by means of a powerful air pump from a central station. The sewage is finally sucked into a steam concentrator at the central station, from which it is pumped into or disposed of on to land or made into poudrette.

CHAPTER XIII.

DISPOSAL OF SEWAGE.

The final or ultimate disposal of sewage in either the dry or wet system is a matter of the utmost concern to a sanitarian; for upon the efficiency with which these are disposed of depends largely the general health of the people. Possibilities of their acting as a source of danger to the public, in Western countries, are rather remote in as much as almost every town or village has a separate filtered water supply. But in India things are different : in villages water supply is almost always scanty, and the people generally have recourse to any available source of water, and consequently the pollution of a tank, river or stream is a matter of great consequence affecting, as it does, the health of the community.

The sewage in the water-carriage system may be disposed of by either of the following methods:—

I. **Cesspool System.**—Cesspools are masonry tanks serving as reservoirs for the reception of the water-closet sewage and waste water of houses. The solid excreta gradually fall to the bottom whence they are removed and trenched. This system must be regarded as only temporary and partial, and is not in vogue in India.

II. **Discharge into a Stream or River.**—This should always be avoided in case of rivers having towns or villages on their banks. Pollution of water in India is attended with greater danger than in England, due to the habits of the people of drinking water direct from rivers.

III. **Discharge into the Sea.**—This may be done wherever possible, without any objection, provided the sewage is discharged well below the ebb-tide flow, so that it may at once be carried away from the shore and diluted by a very large volume of water. To prevent crude sewage being carried back and deposited on the foreshore by tidal currents and wind, the outfall should be well below the ebb-tide level and away from the town.

IV. **Disposal on to Land.**—This method of disposal of sewage is properly speaking a biological one, as the superficial layers of the soil with their myriads of micro-organisms carry on the purification of the sewage and form new substances in its place. The sewage is allowed to pass on to land with or without any preliminary treatment. This can be done by either of the following methods :

(*a*) *Intermittent Downward Filtration.*—By this method sewage is purified by the action of the soil which acts as a mechanical filter, and for this purpose a porous soil should always be selected. In the words of the Royal Commission on the Metropolitan Sewage Discharge, filtration means "the concentration of sewage at short intervals, on an area of specially chosen porous ground, as *small* as will absorb and cleanse it ; not excluding vegetation, but making the produce of secondary importance. The intermittency of application is a *sine qua non* even in suitably constituted soils, wherever complete success is aimed at." But for this purpose the same soil should be used on intermittent principle, *i. e.* should have alternate work and rest. The purification is chiefly effected by soil bacteria or the vitrifying organisms which exist in large numbers in the superficial layers of all soils, particularly in lands rich in organic matter. These organisms require air and oxygen for their development and by feeding on the organic substances of the sewage cause their oxidation. For successful filtration the following conditions are necessary :

(1) The soil must be porous, and the whole plot efficiently drained by means of porous drains laid six feet below and ten feet apart.

(2) The surface of the land must be properly sloped to allow the sewage to spread over the whole area.

(3) The entire land must be divided into blocks, and each one being irrigated for six hours and allowed to rest and aerate for eighteen hours.

The land may conveniently be laid out in ridges and furrows, and cultivation may be carried on the ridges while sewage is permitted to flow down the furrows. The effluent which comes out of the subsoil drain is pure, and does not putrefy, and can be discharged into any river or stream. This method is simple and efficient where plenty of suitable soil is available. One acre (about three bighas) of filter bed, if specially prepared, will dispose of the sewage of about 3000 persons.

(*b*) *Broad Irrigation or Sewage Farming.*—In the interpretation of the Royal Commission on Metropolitan Sewage Discharge, broad irrigation means "the distribution of sewage over a large surface of ordinary agricultural ground, having in view the maximum growth of vegetation (consistently with due purification) for the amount of sewage supplied." The soil should be reasonably porous, and the land selected low enough to allow the sewage to flow by gravitation. It may however be necessary to underdrain the land, if the soil be not very porous, to carry away the excess of effluent to the nearest watercourse. The sewage must be discharged on to land in a fresh condition and the coarser portions removed by precipitation or sedimentation. Irrigation of sewage should not be continuous, but must be intermittent, so that aeration of the soil can take place during the period of intermission. The land is laid out in the ridge and furrow system and the sewage flows down the centre of the ridge towards the furrow. Ordinarily one acre of land is required for about 100 persons in temperate climates, but if there be a preliminary precipitation, and particularly in India where evaporation is greater, a smaller area would suffice. Heavy rainfall greatly hampers with the working of the system.

This method can be profitably carried out in India where land is fairly cheap, and even in the neighbourhood of houses without any danger to health. But it is desirable wherever possible to locate the farms at a fair distance from towns or places of human habitations. It is a comparatively cheap method and the cost of its up-keep is small. Immense crops of coarse grass, such a *dhoob*, can be grown in such a farm. Sugar cane, plantains and other vegetables may also be cultivated with profit, and no harm could possibly accrue by eating such products. Badly managed farms—where more sewage is thrown than the land can purify, or where the sewage is discharged without any intermission—may cause the ground to become sodden, and by retarding purification create a nuisance.

V. **Chemical Treatment of Sewage.**—This process depends on the precipitation of the more solid particles of sewage in so-called settling tanks or reservoirs where they undergo sedimentation. This is effected by the addition of certain chemical agents which act as precipitants and carry down suspended matters with some dissolved organic impurities of the sewage. The clear supernatant fluid called the *effluent* may be further treated or discharged into any water-course or on to any field. The *sludge* or the precipitate is then pressed into cakes and sold as manure. The chemicals commonly used for the purpose are:—

(1) *Lime* (as lime water).—It combines with the carbonic acid of the sewage forming an insoluble carbonate of calcium and also with some of the organic bases of the sewage. the precipitate falls to the bottom forming the sludge. But if lime is added in excess both the sludge and the effluent become alkaline and decompose rapidly. Usually twelve grains of quick-lime is required for every gallon of sewage, but the quantity employed varies with the nature of the sewage. This method though simple and cheap is ineffective.

(2) *Sulphate of Alumina.*—This causes a flocculent precipitate which entangles and carries down most of the suspended organic matters. Lime may also be combined with alum in the proportion of five grains of each to every gallon of sewage.

(3) *Protosulphate of Iron.*—This salt is a powerful antiseptic, and when added to alkaline sewage or to sewage previously treated with lime, a copious precipitate of hydrated protoxide of iron is formed which carries down suspended organic matters. 2 to 5 grains of this salt is added to each gallon of sewage.

(4) *The Amine Process.*—The sewage is subjected to a treatment with a mixture of lime and a small quantity of

herring brine containing a little methyl-anime. A precipitate forms rapidly which is said to be almost odourless.

(5) *The Hermite System.*—In this system the sewage is treated with electrolysed sea water. By passage of electric current through sea water contained in galvanised iron tanks magnesium chloride is decomposed forming a disinfecting fluid which, it is claimed, rapidly decomposes fæcal matters in sewage and effectively sterilises it.

(6) *The A B C Process.*—In this process alum, blood, clay and animal or vegetable charcoal are added to the sewage, when a clear flocculent precipitate results. The dried sludge is known as *poudrette.*

The disadvantages of the chemical treatment of sewage are numerous, and it was hardly ever practised in India, and in places where it is in use it is rapidly being given up. The sludge which falls to the bottom of the settling tanks is very bulky, and the difficulties and expenditure attended with its safe removal and disposal are very great. Moreover, the sludge containing, as it does, organic and mineral matters and about 90 per cent of water has very little manuring value; further, the effluent is not free from pathogenic organisms. The microbes are not removed but the sewage is simply clarified.

VI. **Biological Treatment.**—This process, instead of precipitating suspended matters, reduces the complex organic matters present in the excreta into simpler substances by the action of bacteria and other micro-organisms. Normally two kinds of microbes are present in the sewage, *viz.*, *ærobic* and *anærobic.* The anærobic organisms are chiefly concerned in reducing the organic substances of the sewage into simpler chemical products, chiefly ammonia, by breaking down, digesting and liquefying them, while the ærobic ones convert by process of nitrification the ammoniacal substances into nitrites and nitrates.

The exact changes taking place in the sewage as a result of bacterial action are rather complicated, and the real nature of their action is not well understood, but for practical purposes they are classified by Rideal into three stages :—

(1) The *first stage* or the stage of anærobic liquefaction. In this stage the albuminoid materials, cellulose and

fats are split up into soluble nitrogenous substances, fatty acids, ammonia, gases and derivatives of phenol.

(2) The *second stage* is the continuation of the above, when a further formation of ammonia, nitrites and gases occurs. This stage is in reality a semi-anærobic disintegration of the partially dissolved bodies.

(3) The *third stage* is the stage of ærobic nitrification, ammonia and carbon residues are changed into water, carbon-dioxide and nitrates.

Septic Tanks.—Many varieties of biological installations, such as those of Scott-Moncrieff, Stoddart, Cameron and others, may be mentioned, but that devised by Major Clemesha deserves special mention as it is admirably suited for the tropics. This installation was first devised by Cameron of Exeter about twenty years ago under the name of *septic tank system.* But the first systematic study of the biological process of the treatment of sewage in the Tropics was undertaken by Dr. Fowler and Major W. Clemesha in January 1906, "and an ingeneous arrangement known as the Septic Tank Latrine which consists of a latrine built actually on the roof of septic tank has been in extensive use. These latrine arrangements are particularly useful for communities such as the labour of a mill, for jails, schools, etc."*

In this system there is a marked line of demarcation between what may be called the first stage or stage of liquefaction and the second stage or stage of purification. The sewage is first led into a tank from which light and air are excluded, and the effluent is let out through a discharge pipe at a point half way between the scum and the sludge, and thus large quantities of solid materials are prevented from being mixed up with the effluent. The tank should be thin and about five or six times as long as it is broad; one measuring 60′ × 12′ × 6′ will meet the requirements of about 2000 users per diem with five gallons flush per user. In order to prevent pieces of stones, bricks or hard lumps of fæces from entering the tank proper, and thereby interfering with its true septic action, arrangements should be made to separate these by a partition placed in the tank. This will cut off a portion of the tank into a small compartment known as the *grit chamber*, the capacity of which should be about one eighth of the tank. The connexion between this chamber and the septic tank proper should always be at the bottom, through an opening of about 12 to 18 inches, as it has been found that about 95 per cent of all fæcal masses float in water, and, therefore, cannot enter the tank. Further, the floor of the chamber should have a slope towards the tank with a depression in its centre for bricks and other heavy substances to lodge. It is important that the sewage should be as fresh as possible. *Ventilation* of the tank and grit chamber should be efficient, and carried on through ventilating shafts, and provisions made for inspection and cleansing by means of manholes.

---

* Indian Medical Gazette, June, 1912.

For purposes of description the action of the septic tank on the sewage may be classed as follows :—

The first stage.—The anærobic bacteria attack and liquefy the sewage in the tank where the fæces are broken down and disintegrated and transformed into a state well adapted for nitrification; in fact, this action of disintegration begins in the grit chamber, and if it is allowed to continue for sometime in a suitably designed chamber very little work will be left for the tank proper. The sewage, however, must pass through the tank very very slowly. The gases given off as the result of disintegration are inflammable, and are a mixture of carbon dioxide, methane, hydrogen and nitrogen. Little, if any, sludge is left behind and the ultimate products of decomposition, besides the above mentioned gases, are ammonia and water. The effluent which is rather inoffensive, though dirty-looking, is drawn off without disturbing the black masses (scum) that float on the surface.

The second stage consists in the purification of the effluent by converting its nitrogenous matters into nitrates by the action of ærobic bacteria. This process is of supreme importance in biolysis, in as much as these organisms will carry on the purification thoroughly even in the absence of a septic tank, the action of which is merely of a preliminary nature. The best way of getting the effluent in contact with the bacteria is by passing it through percolating continuous filters or 'contact beds'. These are made up of hard furnace clinkers or *jhama*, cuncurs, gravels, &c.

A *contact bed* is a masonry tank filled up with such materials as jhama, &c., on which the effluent from a septic tank is distributed and allowed to remain for a fixed period, generally two to four hours. The best material for contact beds is fine hard furnace clinker or jhama. Contact beds are generally rectangular in shape and may be of any depth, but one with a depth of three to four feet gives the best result. The materials should be removed, washed and replaced periodically.. It is important that a contact bed should take not more than half an hour to fill or empty itself, otherwise, it would be impossible to arrange the period of rest and contact properly. The period of contact should be limited to four hours, and if prolonged the organisms will die from deprivation of air. For very dilute sewage an hour and a half to two hours' contact with the material and three hours' rest for aeration is necessary, but when the effluent is concentrated, as is generally the case in India, with large quantity of free ammonia and other nitrogenous materials Clemesha considers that a four hours' contact and twenty hours' rest for aeration and digestion of the absorbed nitrogenous material may be necessary.

A *continuous or streaming filter* is a mass of substances like jhama, cinders, &c., scientifically graded from above downwards, over which the effluent is allowed to flow without intermission. The necessary chemical changes occur during the passage of the effluent through the filtering medium. When properly designed and started these filters practically require no attention, but their surfaces require to be scraped once in a month.

It is desirable that the septic tank effluent should not be discharged into a stream from which water is drawn for drinking purposes. It can, however, be satisfactorily disposed of by discharging on to land or sea, or by using it for boilers in mills or factories.

A properly designed septic tank latrine is a thoroughly sanitary arrangement, and is to be recommended whenever the conditions are favourable. It is in the long run economical, for it does away with a large number of sweepers, carts, bullocks and trenching staff that are necessary in a hand removal system.

Merits of the different methods of Sewage Disposal.—Speedy and complete removal of all excrementitious matters from neighbourhood of habitations is the primary object to be aimed at. The dry method is not efficient as the removal of excreta is undertaken at intervals, and does not satisfy all the requirements. For large towns the water-carriage system is the only efficient method of removal of night-soil. It should not be discharged into any river or stream, but where suitable land is available either intermittent filtration or sewage farming may be undertaken. By land filtration an effluent is usually obtained which may be discharged into a stream, the water of which is not used for drinking purposes. Irrigation, besides giving the above-mentioned results, has the advantage of rendering the land more fertile by holding up certain ingredients having some manurial value. Where land is not available the sewage should be treated biologically. This is by far the best method as it is based on a solid scientific principle, besides being thoroughly efficient and economical. But the effluent obtained by this treatment is not, as a rule, harmless, and therefore cannot be permitted to run into any watercourse without subjecting it to a land or special sand filtration.

CHAPTER XIV.

DISPOSAL OF THE DEAD.

Strange indeed are many of the ceremonies attending the disposal of the dead in different parts of the world, and following the natural order of things, the more primitive the nation the more primitive its methods. The rudest mode now prevalent is that of simply leaving the body exposed, but the ways of exposure vary considerably. Some wandering tribes act on the maxim "Where the tree falls, there let it lie," and, leaving the dead behind, move their camp to pastures new. The Wanyamwesi in Africa, however, carry their dead into the forest to be devoured by beasts of prey, while some of the tribes of Guinea throw the corpse into the sea. The Kamtchadales keep dogs to consume their dead, under the strange impression that those who are devoured by dogs will be the masters of fine dogs in the world beyond. The Parsees, place their dead in a round tower, called a Tower of Silence, and the vultures who make such towers their habitation finish the work. In Dahomey (west coast of Africa) it has been stated that a person whose body has been struck by lightning is hacked in pieces and devoured by the priests.

Burial, of course, has many different forms, the simplest of which is perhaps the piling of stones or thorns over the body to keep off wild beasts. Some tribes bury their children by the roadside, so that their souls may enter into the bodies of the passers-by. *Cremation*, perhaps, is an earlier custom than that of burial in the earth, *embalming*, or *drying* the body by suspending it from a tree, and many nations have more than one custom—for instance, burying their women only, while the men are embalmed or dried. An instance of several customs being in common use in one tribe is to be seen among the Kalmucks; they either expose, bury, burn, throw the body into the water, pile over it a heap of stones, or build a hut over it, doing whatever the priest considers to be the most suitable. The position of the body also varies considerably, but as a general rule the head is laid either to the east or to the west; the Bongos, however, are an exception, for they bury the women with the face to the south, and the men with the face to the north.

Safe disposal of the dead in a manner so as not to affect the public health is an important sanitary problem. Customs associated with its disposal are too well established. Any modification, therefore, in the direction of improvement—whenever the existing methods are opposed to sanitary ideals—should be made "having due regard to the sentiment of the relations and the populace generally and to the religious observances peculiar to each sect." Of the different methods in vogue, *cremation* and *earth burial* deserve special notice. The method of removal of the dead for disposal is no less important. The usual practice in India is to carry the body on a *charpoy*; but with certain classes it is often carried tied on to a piece of bamboo. Moreover, the bodies are not always properly covered. Such a practice is not only unsightly but unhygienic.

Cremation or Burning.

Cremation may be said to have been the general practice of the ancient world, with the exception of Egypt, where the bodies were embalmed; Judæa, where they were buried in sepulchres; and China, where they were buried in the earth. This is the most satisfactory method of disposal of the dead, and is the old established custom with the Hindus. By this method the body is reduced to a small quantity of odourless ash within about three hours. The usual fuel is ordinary wood, and costs about four rupees (six shillings). When any special kind of wood, *e.g.* sandal wood, is used the cost becomes higher. This method has the advantage of not only being cheap, but prevents pollution of soil and water, and if properly carried out it is quite sanitary.

The chief objection to this method is that it affords facilities for concealing evidences of crime. By making proper arrangements for examination of the dead bodies, or by insisting on the production of a death certificate from a qualified medical man, such an objection may be overruled. Poisons, like copper, arsenic, &c., might be detected from the ashes or unburnt pieces of wood. It is desirable, whenever possible, that burning places should be at least 500 feet away from any inhabited locality.

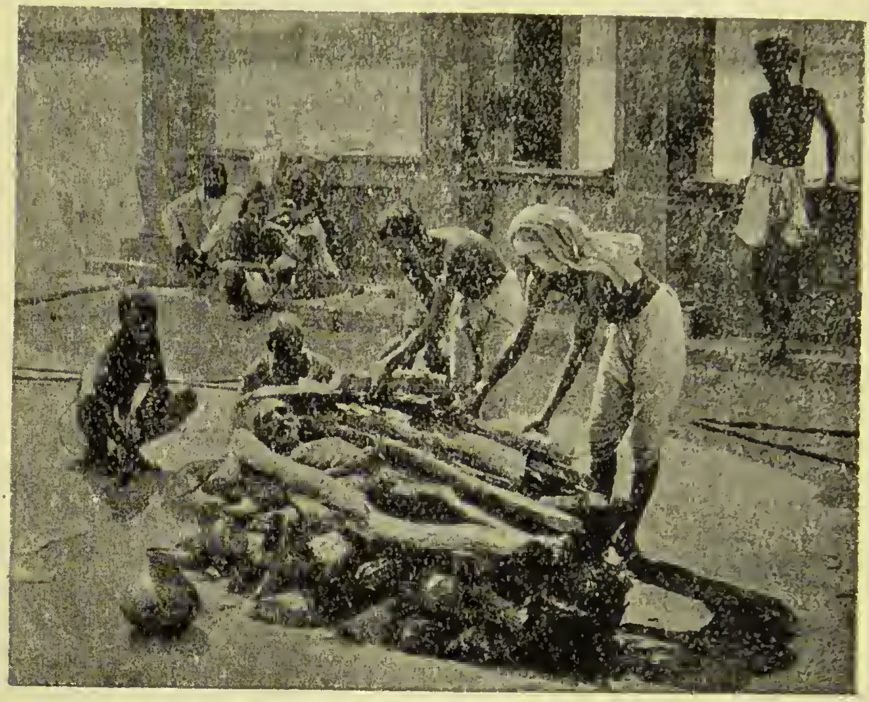

Fig. 18.

A Calcutta Crematorium (burning ghat) for the Hindus.

Cremation is becoming popular with the Europeans, and a crematorium has been established in Calcutta. A properly designed crematorium will consume a body in about two hours, leaving about three pounds of ash. All offensive gases are got rid of by conducting the smoke through a furnace.

EARTH BURIAL.

The object of burial being speedy resolution and complete oxidation, the soil best suited for the purpose is a sandy or calcareous loam. This should be reasonably porous and light, and either naturally or artificially drained to a depth of eight feet. Clay soil is bad as it cannot be drained properly, and allows the products of putrefaction to escape through cracks in dry weather. The same objection applies to a chalky soil. Burial is not unattended with dangers : a certain amount of irrespirable gas, *e.g.* CO_2, will escape into the air, or into sewage drains, and thus reaches houses, or will percolate so as to contaminate water. The great Paris cemeteries inflict headache, diarrhœa, and ulcerated sore-throat on their immediate neighbours.

In the selection of a burial ground the following points should be attended to :—

(1) The ground should not be high, as the natural drainage may pollute the water supply at a lower level.

(2) The area should be marked into plots, and provided with pathways at convenient intervals.

(3) The area should be outside the town, and trees and shrubs should be planted to absorb the carbonic acid.

Ordinarily a space of 9 feet × 4 feet is allotted for adults, and $4\frac{1}{2}' \times 4'$ for children under twelve, and an acre of land is required for about 4000 people for fourteen years. Deep burial should be avoided, and a space of at least two feet should be left between the level of the subsoil water and the dead bodies. The use of metallic or strong wooden coffins, brick graves or vaults, helps to preserve the bodies for a long time, and thus interferes with their proper resolution and oxidation. Bodies should be interred in easily destructible coffins, three to five feet below the surface of the earth, where the micro-organisms exist in abundance. Too shallow a burial should be avoided as there is risk of the graves being dug up by jackals or other animals. It takes about a year for the soft parts to disappear inoffensively.

CHAPTER XV.

PERSONAL HYGIENE.

Personal hygiene is not only concerned with matters touching the health of the individual, but also embraces certain personal factors conducive to good health. They are : habit, constitution, heredity, idiosyncrasy, temperament, cleanliness, clothing, exercise, &c.

Habit.—Habit plays an important part in the preservation of health. It is readily formed, grows by practice, and eventually becomes a part and parcel of nature, making its eradication a matter of very great difficulty. It is for this that habit is called second nature. Influence of habit in the formation of character of individuals is known to all, but its influence on the physical and mental condition of men, particularly of children, can never be overestimated. Indeed, it is productive of good and abortive of evil. A child brought up under healthyhygienic environments will not tolerate the shutting up of all doors and windows or other ventilating openings. This subject may be discussed under the following heads, which are more or less influenced by habit.

(*a*) *Eating and Drinking.*—A regular habit with regard to eating and drinking is of essential importance for the preservation of health. Food, which must always be healthy and wholesome, should be properly masticated and eaten slowly. It is a bad habit to overload the stomach. Alcohol as a rule, should be avoided, and the very fact of its craving is an indication of ill-health.

The following are some of the points which should be carefully attended to :

(1) Always wait for a true appetite.

(2) Select the food the appetite particularly craves at the moment.

(3) Masticate well.

(4) Do not swallow a mouthful unless it swallows itself.

(5) Avoid reading during meals.

(6) Agreeable society at meal times is advantageous.

There are certain noteworthy differences between those who are beyond sixty and those who are in middle life as regards physiology, pathology, tendencies to disease and resistive vitality. This is particularly noticeable with regard to the two most important functions of animal life—eating and sleeping. Long ago Hippocrates declared in one of his aphorisms, "The old stand fasting much better than those of middle age, and those of middle age much better than the young. Children are very easily hurt by lack of food." This is the keynote of eating among the old. They need less food than in earlier years, and if they insist on eating as much as formerly they suffer from it. It is rather easy to understand the reason for this. They are not nearly as active as in middle life, and their heat processes within the body are much lower. As a consequence they do not burn up so much fuel, and if the fuel continues to be provided in excess for this heat engine, that the animal part of man is, it will not be long before the firebox will be clogged and before processes of various kinds within the body will be seriously disturbed.

Moderation in Eating.—Above all, it is important that long established habits of eating shall not be disturbed in the older years, specially in the direction of more abundant eating than before. Many a man who after a reasonably long life of simplicity in eating comes into conditions of life where dining becomes a function and course dinners and luncheons and breakfasts a routine, suffers severely from it. It is in these cases literally that men sometimes "dig their graves with their teeth." Moderation in eating is of the first importance for the old.

(b) *Smoking.*—Smoking is not essential and should be avoided by young persons. *Hooka* or hubble-bubble is a better way of smoking tobacco. It is said that the smoke in passing through the water in the hooka is deprived of the nicotine and other injurious substances. Tobacco smoking has a soothing effect, and gives to the smoker a peculiar feeling of pleasure. Excessive smoking, or when smoked for the first time, produces sickness, a feeling of depression and muscular weakness. Smoking sometimes affects the heart and inveterate smokers may be the victims of occasional fainting fits. The worst habit is tobacco chewing, for, even if the saliva be not swallowed a greater portion of the juice is absorbed.

According to Sir Joseph Fayrer "it frequently disturbs the equilibrium of the nervous system and the action of the heart, causing nervous giddiness, muscular tremor and palpitation, it impairs digestion, depresses the system mentally and physically and muddles the intellectual system. Cancer of lip and tongue and chronic inflammation of the back and sides of the throat are often ascribed to it. We would counsel those who have acquired the habit and declined to relinquish it, to smoke the mildest tobacco—as seldom as possible—only after eating, and never in the morning, or not till after lunch; or, what is still better, not till after the evening repast."

(c) *Sleep.*—This is the only form of complete periodical rest of both body and mind. Alternate periods of rest and activity are common to all living beings. Action involves destruction and discharge of function implies consumption of structure. Waste must be repaired and the repair must be equal to the waste. The necessity for sleep arises from the demand of certain nerve centres which undergo waste during the hours of activity. With the coming on of sleep the muscles commencing from the extremities become relaxed and is followed by the closing of the eyelids resulting from the inactivity of their muscles. Hearing is the last sense to be dulled. The heart, the lungs, and the digestive tract and other organs continue to perform their respective work during sleep. Sleep interferes with metabolism but stimulates the power of assimilation, and as such favours the absorption of foul vapours.

Sleep is really rest of the brain, but the spinal cord and the sympathetic system never sleep. Like other forms of rest it varies in degree and may be very slight—mere drowsiness, or very profound—complete cessasion of all the functions depending on the centres of the brain.

The amount of sleep varies with age, occupation and habit. Excessive sleep makes the brain less active, while its deficiency leads to prostration and general restlessness, and sometimes to sleeplessness. The amount of sleep required varies with—

(i) *Age.*—Infants sleep the greater part of the day, and the duration decreases as age advances; adults requiring about six hours' sleep. The most important factor for the retention of health in age is sleep. Those above sixty need more sleep than they did in middle life, or at least need to spend more of their time in a reclining position. It is not absolutely necessary that they should sleep all the time, but they ought to spend at least eight hours lying down with all portions of the body on about the same level, so as to save their hearts the necessity for pumping blood against the force of gravity. It must not be forgotten that some two gallons of blood—that is, sixteen pounds—goes through the heart about every minute. The merely mechanical labour performed by the heart muscles is enormous. The saving of the heart by lying down is an extremely favourable factor for old hearts. Besides, the old should lie down for some time about the middle of their working day. If they get up a little after seven o'clock and stay up until nearly eleven, the sixteen hour day should be broken between two and four o'clock by a prolonged interval of lying down.

(ii) *Sickness.*—Weak, debilitated and sick persons require more sleep and repose than healthy ones.

(iii) *Occupation.*—Persons engaged in brain work require more rest and sleep than those doing physical labour.

To sleep immediately after meals is a bad practice. The old adage "after supper walk a mile" holds good at all times. It is a matter of indifference in what posture a person sleeps, but sleeping on the back is a bad habit. "Sleep not on your back or in the posture of a dead man" is an old saying of Hippocrates. The bed should be firm and elastic, and exposed to the sun daily. The head should always rest on a pillow, and the body, barring the head and face, covered with a sheet. The pernicious habit of a number of persons sleeping together in the same room and of covering the head and face is partly responsible for the feeble and weak health of the people of this country.

Mid-day Sleep.—"In India and other hot climates the tendency to indolence or lethargy is promoted by the heat, whether dry or moist, and more particularly by a hot, muggy, humid atmosphere, as in Calcutta, Dacca or Bombay. To yield too much to this feeling, which only requires encouragement to degenerate into a confirmed habit is injurious," is the opinion of Sir Joseph Fayrer. But it seems that a good nap especially in the summer, particularly with those engaged in active work in the morning, is not only highly refreshing but invigorating.

Constitution.—Individual differences in the constitution exist in different persons. Some are strong and robust, while others are feeble and weak. Moreover, resistance to susceptibility to disease varies with the constitution. A man with a strong or robust constitution does not fall an easy victim to disease.

Constitution of a person is partly acquired and partly inherited, and a strong constitution may be enfeebled under unhygienic conditions, while a delicate one may improve under hygienic ones.

Heredity.—This has a great influence on health. Certain diseases are generally transmitted to the offspring, *e. q.*, gout, insanity, syphilis, &c. The appearance in one individual of traits not possessed by his parents, but known to have belonged to his more remote ancestors is termed *Atavism*. Mental peculiarity and similarity of feature are often inherited.

Idiosyncrasy.—By this is meant a peculiar susceptibility of some persons influenced by certain morbid agencies or medicinal preparations, *e.g.* appearance of nettle-rash with some as a result of taking shell-fish.

CLEANLINESS.

The most important condition of healthful growth and development is cleanliness. Dirt is not only harmful but antagonistic to our very existence. Cleanliness with regard to the food we eat, the air we breathe and the water we drink is imperative for good health. In India cleansing of the skin is of immense value in as much as the amount of perspiration and excretion of solids is considerable. In fact, much of the work of the kidneys and lungs are performed by the skin in hot countries. The sweat glands which open on the surface of the skin help to relieve the body of a portion of the effete material. If they are blocked up by dirt not only their action is interfered with and extra work thrown on the lungs and kidneys, but they form favourable sites for the production or propagation of diseases of the skin. It is therefore of primary importance to see that the orifices of these glands are kept clean. The sebaceous glands secrete an oily substance which acts as a natural pomade. Certain parts of the body like the armpits give out an unpleasant odour from their secretions and so require regular cleaning. It is evident, therefore, that the skin requires proper attention and cleaning. The scarf skin, if not removed, will obstruct perspiration at the mouths of the glands, producing retention and may thus interfere with the respiratory action of the skin. Further, the saline ingredients of sweat help to keep the skin moist by virtue of their hygroscopic properties. Cleansing of skin is best effected by soap and water.

Soap.—When an oil or fatty acid, *e,g.*, palmitic, stearic or oleic, is acted upon by an alkali (sodium or potassium salt) soap is produced, with glycerine as a bye-product. Potash soaps are known as *soft soaps* and they are highly deliquescent; while soda soaps are called *hard soaps*. Excess of soda irritates the skin.

The following are the common varieties of domestic soaps :

Toilet Soaps. — These are generally prepared from lard, marrow or sweet almond oil. They are coloured by special pigments and variously perfumed. Brown Windsor soap is made from the residue of refined fats and perfumed with oil of bitter almonds.

Marine soaps are made by the action of soda or potash upon cocoanut oil and is not rendered insoluble by brine, and, therefore, they form lather with sea water. By mixing resin with tallow or palm oil, *yellow soap* is formed ; this is somewhat rough and firm. *Castor oil soap* prepared with castor oil and soda is very emollient. *Normal soaps* contain 15 to 35 per cent of water ; "liquoring" consists in adding 5 to 25 per cent of soluble glass or silicate of soda to a soap. By this process soap is made to contain 70 per cent of water. *Glycerine soap* is ordinary soap to which glycerine has been added.

It should be observed that individually the substances employed in the manufacture of ordinary soap are ill-suited for the purpose of cleansing the skin. Caustic soda is corrosive and dissolves the cuticle, while the oils and fats do not mix with water. But by their chemical action a new compound is formed which is almost harmless to most skins and their destructive qualities are entirely lost. The *rationale* of the cleansing action of the soap is as follows :

"The dirt adhering to the body is mostly composed of dust and other extraneous matter combined with the perspiration and the greasy excretion from the skin. When ordinary hard soap is brought into contact with water it is decomposed and gives off part of its soda, which unites with, and removes from the skin, the unctuous dirt thus rendered miscible in the water used for washing. As the more the liberated soda is diluted the less will be its caustic effect on the skin, it is clear that a liberal supply of water should accompany the use of soap in personal ablution." (Malcolm Morris).

In India inunction of the body with some bland oil before bathing is a very popular custom. The oils usually used are either the expressed oil of mustard or cocoanut, either by itself or perfumed. The utility of such a practice is evident. It not only keeps the body cool, renders the skin soft and supple, and helps the introduction of a certain amount of fat, but entangles the dirt of the body and facilitates its removal during bathing, especially when soap is used. Moreover, it facilitates shampooing or massaging of the body which may with advantage be taken just before a bath. By kneading and rubbing the circulation is quickened and the muscles exercised, giving the person an exhilarating and refreshing feeling.

Baths.—Baths are necessary not only for cleanliness but also for their beneficient action on the skin and internal organs. According to Professor Braun baths are less needed by those who perform muscular work, because the functions of the skin and perspiration are sufficient in themselves to perform the task of cleansing. Baths may be classified according to the temperature of the water as follows:—

Cold	33° to 65° F.
Cool	65° to 75° F.
Temperate	75° to 85° F.
Tepid	85° to 92° F.
Warm	92° to 98° F.
Hot	98° to 112°F.

Warm Bath.—It has a stimulating action on the skin and reflexly excites the heart and circulation. Napoleon used to have recourse to a warm bath instead of yielding to sleep after a battle. As a cleansing agent, warm bath, when used with soap, is the best. It increases the danger of chills if there is subsequent exposure, but this sensibility to cold may be obviated by a rapid cold sponging and then drying the body quickly.

Cold Bath.—The first effect produced by a cold bath is one of shock followed by contraction of the superficial blood vessels, but the vessels dilate very soon giving the person a feeling of warmth and pleasure. Cold baths should be taken as quickly as possible and the body covered immediately afterwards. People living close to the sea, lake, river, &c., usually take 'plunge baths'; these are beneficial to the young and the healthy, and for those possessing the power for ready reaction, but care should be taken not to remain too long in the water.

Baths should not be taken during a fast, or just after a full meal, or during exhaustion. The best time for taking a bath is the morning; if taken at night it should, as a rule, be a warm one.

The skin is a delicate organ, and when covered by clothing becomes highly sensitive to thermic influences. Hence the people of India, who are accustomed to keep their body bare, rarely suffer from the effects of cold to the same extent as the Europeans. The temperature of the bath should first of all be such that can be borne without discomfort; then it should gradually be altered, and in this way only sensitive skins may be brought to bear perfectly cold water. But the temperature of water should always depend upon what is called the power of reaction, that is readjustment of the free cutaneous circulation without giving rise to any internal congestion. Sometimes instead of that pleasant feeling of exhilaration, vigour and greater capacity for mental and physical work, the reaction is delayed and the vessels remain constricted, as evidenced by a sensation of fullness of the head and abdomen, faintness, tight feeling over the chest and depression. Then the cold bath is unsuited and must be discontinued. Under such circumstances the water should have the chill off, be tepid, or even warm.

Personal Cleanliness.—This involves attention to the skin, mouth, nails, hairs and other parts of the body. The mouth should be kept perfectly clean and teeth regularly attended to. Tomes gives the following directions for the proper management of teeth: "The teeth should be thoroughly cleaned at least twice a day with a brush of only moderate hardness; and if the teeth are inclined to decay between, or there are fillings between them, floss silk should be carefully passed through, so as to thoroughly clean, the surfaces. Any place where the food habitually lodges, and whence it is not promptly removed, is quite sure to decay sooner or later; and on the other hand teeth rarely decay on a fully-exposed surface. It will be seen, therefore, that most scrupulous cleanliness is the best of all preservatives for the teeth, and that the more delicate they are, the greater the need of frequent and thorough brushing—a thing which can hardly be overdone." Carious teeth should be "stopped."

The *tongue* should be cleansed by a tongue-cleanser every morning. The *nails* require to be kept clean and cut short, otherwise dirt will lodge inside and may carry infection. The *hair* requires to be daily brushed and combed. The chief necessity for the hair is not so much daily ablution, for this may be carried to excess, but cleanliness. Proper and thorough cleansing is required both for men and women. This is best done with soap and hot water, or yolk of egg, washing soda, or better still by the use of *soap nut* solution (water prepared by steeping soap nut for a few hours). One should always practise to shave himself and must avoid a barber's razor. Money spent on a shaving set is a profitable investment.

Clothing.

The principal objects of clothing are :—

(1) to afford protection to the body against heat and cold, and external injuries ;

(2) to assist in the maintenance of bodily heat ;

(3) for personal decoration and ornamentation (of lesser importance).

A perfect dress, therefore, should fulfil the above requirements. The materials for the dress should be such as to exercise no harmful effect on the skin directly in touch with it. Children and old people are very susceptible to changes of temperature and are more prone to suffer from congestion or inflammation of the internal organs ; particular care should therefore be taken in the matter of their dresses.

The normal body temperature, which is 98·4°F., is solely derived from food, and clothing, by preventing too rapid escape of animal heat, acts as an adjunct to food.

The following points should be considered in the selection of materials for dress :

(1) The dress should in no way interfere with the healthy action of the skin ; for this purpose porous materials which absorb moisture readily should be preferred. The use of flannel or gauze banians next to the skin lessens the liability to attacks of chill. Certain materials absorb heat and are non-conductors, others again reflect more. By a careful selection we can so prepare our clothing as will suit all climates and seasons. In cold weather the non-conducting properties will not permit the escape of the animal heat excepting in a very tardy manner, and during hot weather they will be slow to conduct heat to the skin from without. The greatest amount of heat will be derived from wool and the least from linen.

The influence of colour has some significance. It is of little consequence whether the dress worn next to the skin is red, blue or white, as long as it will maintain the proper heat of the body. But it makes a great deal of difference with regard to the heat that acts upon the body from without. The same material will absorb different amounts of heat when dyed with different colours.

(2) All tight clothings should be avoided, as they interfere with circulation, respiration, digestion and the action of muscles. Other things being equal, loose dress is warmer than tight-fitting ones. In the loose fitting garments there is a stratum of air between the skin and the articles of dress which has an important influence on the bodily heat. Air is a bad conductor of heat, and here it acts in the same way as a separate garment. Garters of every description should be condemned—they compress the superficial veins and give rise to a feeling of heaviness and may lead to the development of vericose veins.

(3) The warmth of the clothing should be distributed throughout the body uniformly.

(4) All clothings should be light and warm, and their weight should be uniformly distributed.

(5) They should not have any irritating or poisonous action on the skin. Certain clothes are coloured with poisonous dyes and the poison generally used is arsenic. Some materials again have an irritating or stimulating effect on the

skin, depending on its sensitiveness and the susceptibility of the individual. Some persons cannot wear woollen or flannel underwear; but the body accommodates itself to a variety of circumstances, and a sensitive skin becomes very soon accustomed to the stimulation and ceases to respond to a rough garment.

MATERIALS FOR CLOTHING.

The materials used for clothing are derived partly from the animal and partly from the vegetable kingdom. From the former is derived wool, silk, fur, leather, &c.; and from the latter—cotton, hemp, flax, &c. Of these wool, silk, cotton and flax are the most important and commonly used. These can be distinguished by their physical and microscopical characters and by chemical reactions.

Wool.—It is the natural covering of many animals. Its value depends upon the presence of oil and fat, and in the form of cloth it imprisons a certain amount of air between its interstices, thus preventing heat passing through it. It therefore forms a valuable garment in India during winter. Its hygroscopic property is of much value in the hygiene of clothing.

During profuse perspiration, wool absorbs water and diffuses it through its meshes. This water undergoes evaporation, but the cooling effect which might have been harmful to the body is directed towards the garments and is removed from the skin. As an underclothing, therefore, woollen garments have overwhelming advantages, and of all materials they are best suited for varying circumstances of life. Wool is, as a rule, heavy and often irritates the skin when worn next to it. But this has a therapeutic value depending on its stimulating the circulation. For the old, the delicate, the scrofulous and the rheumatic, woollen underdress is specially beneficial. Woollen materials are less cleanly than the cotton or linen ones, because they soil less readily and show less the outward signs of dirt, and shrink on washing. Woollen garments should be smooth and soft and the texture should be close. In the form of flannel, merino, cashmere, alpacca, felts, shawls, puttoos, &c., wool is usually worn.

Silk.—Silk is a fibrous substance spun by the silkworm. The fibres are about $\frac{1}{2000}$th inch wide having no scales or surface markings. It is a bad conductor of heat, less absorbent than wool, but better than cotton. It is soft, smooth and gives a soothing feeling to the skin, and is therefore the best material for underwear.

Satin is a special preparation of silk with a smooth polished surface.

Leather.—Leather is chiefly used for boots, but being very close and firm in its texture forms an exceedingly warm clothing, as it allows no air to penetrate through it. The skins of ox, sheep, horse and goat are generally used. It is impervious to moisture and therefore keeps the skin not only hot but clammy. The chief objection to its use is that it gets stiff when dried after washing.

Feathers.—Their use is more for ornamental purposes than for covering the body. Pillows and quilts are often stuffed with them.

Cotton is the downy hair enclosing the seeds of the different species of the plant *gossypium.* The fibres are flat and ribbon-like, varying from $\frac{1}{1000}$th to $\frac{1}{4000}$th inch in thickness. Cotton has the advantage of being hard, durable and cheap. It absorbs odours readily, is warmer than linen, and does not shrink on washing. Its fibres are hard and it is inferior to wool as a warm clothing. It is mixed up with woollen materials to increase their durability and to prevent shrinking. It is a good conductor of heat and conducts to the skin the heat from without and allows the body to be rapidly influenced by the conditions of the external atmosphere. But cotton materials unlike woollen fibres have a very feeble hygroscopic property.

Cellular cloth is made from cotton, and the fibres are so woven as to leave cellular air interspaces in the texture. The enclosed air being a bad conductor helps to retain the heat of the body.

Linen.—This is made from flax which is formed from the fibres of the flax plant. It is a good conductor of heat like cotton and bad absorbent of moisture. It has no advntage over cotton as an article for clothing; as it can be woven into finer materials it takes a higher finish.

Socks or stockings should always be worn with boots or shoes, although the practice with most people in India is to do away with them. Woollen socks are by far the best. They should not be very tight or pointed at the extremity; when too short they cramp the toes and when too long, as often happens with children with the object of "allowance for growth," a mass of superfluous material remains at the extremity of the boot. They should be put to the sun daily as they smell badly from perspiration.

Boots and Shoes.—They should conform to the normal outline of the sole. The measurement of the foot should be taken when resting on the ground and always over a thick pair of socks. It is better to have a size bigger than is actually necessary. The sole should be flexible : a rigid sole destroys the main action of the foot in the act of walking. The leather should be soft and pliable consistent with the strength. Thin frail boots that are worn by ladies are mere apologies for foot covering. According to Lukis and Blackham boots should be worn in preference to shoes to protect the ankles from the bites of mosquitoes.

Clothing for Children.—The general principles already laid down apply equally to children; but certain conditions render the dress of this period of life a matter for special consideration :

(*a*) Infants require to be properly protected by clothing. In the early life the heat-producing power is feeble and the loss of heat by evaporation is very great. "Their clothing should be soft, light, warm and loose. The notion that by clothing children lightly and by exposing them at an early period to cold, they become accustomed to fluctuations of temperature and are hardened" is a delusion, and is accountable for no small contribution to infant mortality.

(*b*) The dress should be loose and free from constrictions.

(*c*) Under no circumstances should the garments be tied tightly to the waist. They should be light and in number consistent with the due protection of the body.

(*d*) The body should be perfectly and evenly covered with clothing.

EXERCISE.

The necessity of exercise for the preservation of health cannot be over-estimated, yet perhaps few realise the importance of the changes it involves. Exercise is essential for the different organs of the body to work easily and effectively. It is also necessary to excite the demand for oxygen required for utilization of food and to promote repair and formation of tissues. It is extremely important for old age not to lapse into habits of inactivity ; there is the temptation of a man well on in years to give up walking to a great extent, to ride in carriages and to sit in the house a great deal. What has been learnt about the heart in recent years shows very clearly that unless it gets a certain definite amount of exercise it does not do its work as well as it otherwise would. According to Parkes a man takes about eight and a half ounces of more oxygen on a "work day" than on a "rest day." Exercise should therefore be taken in the open air to allow a free supply of oxygen for the demands of nature. Physiological exercises are useful in the following ways :*

(1) To develop the weakly and the overgrown.

(2) To restore those convalescent, whether generally as from illness, or locally as from injury.

(3) To correct during youth various deformities.

(4) To relieve certain conditions—as debility and obesity.

(5) To relieve local conditions after certain lung diseases.

(6) To preserve the healthy tone of the body who by necessity or habit, virtue or vice, cannot do so in their ordinary life.

(7) To enable the body to counteract the baneful effects of educational efforts focussed on the mind.

(8) As an educational measure for the mentally deficient.

---

[*] Albutt's System of Medicine, Vol. I.

EFFECTS OF EXERCISE ON DIFFERENT ORGANS.

(1) *Respiratory System.*—During exercise the action of the lungs should be thoroughly free, and there should not be any impediment to the full play of the chest by dress or any other means. The pulmonary circulation is quickened, the amount of air inspired and of carbon expired is greatly increased. It is obvious that increased output demands increased supply of food and fresh air. Alcohol diminishes the excretion of CO_2 and should thefore be avoided during exercise.

(2) *Circulatory System.*—Active exercise increases the force and frequency of the heart with acceleration of circulation, but this is followed by a period of depression.

(3) *Muscular System.*—The nutrition of muscles is improved which contributes to their growth and energy. It seems probable that muscles lose water during exercise.

(4) *Cutaneous System.*—Exercise promotes the action of the skin, which becomes red. It leads to engorgement of the vessels with increased perspiration which in evaporating from the surface of the skin reduces and regulates the temperature. But during active exercise there is less danger of chill, as the loss is replaced by a rapid supply. The risk however increases after exercise and therefore the surface of the body which was exposed during exercise requires to be covered and protected from undue loss.

(5) *Urinary System.*—The excretion of urea is unaffected, but uric acid is increased. On account of the stimulating action of the skin the watery portion and the chlorides of urine are diminished.

(6) *Nervous System.*—Men engaged in brain work must recreate themselves with active exercise which leads to perfect performance of mental work.

(7) *Alimentary System.*—The amount of fæces passed is lessened, and by removing constipation it induces regular action of the bowels.

Effects of Exessive Exercise.—Excessive exercise causes either nervous or muscular fatigue. Mental fatigue is an important factor particularly with the young, the weak and the invalid. For those with a sedentary habit it is best to have recourse to graduated exercise which requires some effort of the mind and will in its execution. Riding, rowing, swiming, &c., may with advantage be undertaken by them. For neurasthenic people an opposite course demanding least nervous effort is necessary.

Diseases of the heart—such as palpitation, hypertrophy, &c, or muscular wasting, may be caused by excessive exercise. After exercise the body should be washed or sponged, and since exercise increases elimination of water, salts, carbon and nitrogen from the body it is essential that these should be replaced. Along with exercise rest is equally necessary, and it is said that excessive exercise lowers the opsonic index even in perfectly healthy persons.

Amount of Exercise Necessary.—It is rather difficult to determine even in the case of an average man the amount of exercise that should be taken to maintain health. According to Parkes an ordinary day's physical work for a healthy man is equivalent to raising 250 to 350 tons one foot high ; this is a moderate amount, 400 tons being a heavy day's work. The amount of muscular exercise involved in this may be easily known by remembering that a walk of 20 miles on a level road is equivalent to about $353\frac{2}{3}$ tons lifted one foot ; and that a walk of ten miles while carrying 60 lbs. is equivalent to $247\frac{1}{2}$ tons lifted one foot. (Haughton).

To estimate the amount of work done by a man in walking the following formula is generally used :

Let W = Weight of the man in lbs.
W' = Weight he carries.
D = Distance walked in feet.
C = Co-efficient of traction.

Then $\frac{(W + W') \times D}{2{,}240} \times C =$ foot tons (2,240 is the number of pounds in a ton).

The following rules should be observed with regard to exercise.

(1) Exercise should be taken in the open air, repeated daily about the same hour and never taken just after or before a meal.

(2) Every part of the body should share in the exercise.

(3) Exercise should be regular and systematic.

(4) Chills should be avoided after exercise.

(5) Amount of exercise should be regulated according to the age and physical development of the person.

CHAPTER XVI.

CLIMATE AND METEOROLOGY.

The climate of a place or region is the sum total of all the meteorological conditions in their relation to animal and vegetable life. It was formerly supposed that the climate of a place was dependent upon its distance from the equator. Although this is an important factor in the determination of climate there are other conditions which also materially affect the climate of a particular place. They are :—

(1) The altitude.
(2) Distance from the sea.
(3) Prevailing wind.
(4) Nature of the soil.
(5) Proximity of mountains and hills.

Besides the above certain other conditions affect the climate of a given locality :—

(*a*) Cultivation of the soil.
(*b*) Presence of marshes, tanks, &c.
(*c*) Presence or absence of forests.

There can be no doubt that climatic conditions have an important effect on health, as is evidenced by the geographical distribution and seasonal prevalence of disease. Further, it is a known fact that climate is an important factor in determining the characteristics of the races of mankind. Amongst these may be mentioned variations in the pigmentations of the skin. There are other variations chiefly due to environment developed in the course of many centuries. In the north west of India the dry climate and the constant struggles with man and nature have combined to produce a race brave and hardy with much physical development.

ACCLIMATISATION.

Acclimatisation literally means adaptation to a particular climate. There are two views regarding acclimatisation. One school holds that acclimatisation is impossible and that Europeans can never be acclimatised in a tropical climate. According to them deterioration caused by climatological factors and endemic diseases will either kill them or render their existence impossible. While Livingstone, the late Bishop Hannington and Dr. Sambon are of opinion that *rapid* acclimatisation is possible for Europeans. But it appears that although acclimatisation of Europeans is possible in course of time, any attempt at rapid acclimatisation has an influence injurious to health. If carefully selected individuals are allowed to colonise in well chosen tropical areas with facilities for occasional changes to the hills, there is no reason why acclimatisation should prove an impossibility. But this must be very slow, and persons with a tendency to any chronic disease like gout or rheumatism, diabetes or albuminuria, or those suffering either from acquired or hereditary syphilis, are not so well suited for the purpose.

Acclimatisation is effected by a slow process of change taking place either in the individual or in the race by constitutional modifications brought on in different generations. The history of the human race reveals that the body adapts itself to the circumstances and conditions in which it is placed. All Europeans however cannot be acclimatised in a given area equally. Besides climatology of their original residence, the habits, customs and other peculiarities have to be taken into account with regard to their adaptibility for emigration. But this much can be said that selected persons from almost every European nation may thrive all over the world.

Rapid acclimatisation with regard to Europeans is only possible in the temperate zone. It has been suggested that acclimatisation of Europeans in India is impossible unless they intermarry. But this is not true acclimatisation ; for, the race is altered and transformed into a mixed race, which ultimately has very little in common with the original stock. It may be said that any healthy European can live without much physical deterioration for at least five years continually in Indian climates. Conversely, instances are not wanting where Indians have settled in European countries for years together without any harm to their health and body.

"Race itself does not always provide us with a definite proof to capability of acclimatisation, for in India the Hindu population, notwithstanding its Aryan origin, has thriven under unfavourable circumstances, and even in malarial districts, presenting a striking contrast to the English (also an Aryan race), whose intolerance of the Indian climate is obvious".*

CLIMATE IN RELATION TO HEALTH.

Various meteorological conditions have important influence on climate and health. Of these temperature, humidity, and atmospheric pressure demand special consideration.

Temperature.—The temperature of the air influences the climate, and forms the basis for its classification. The chief source of heat in the atmosphere is the sun, but distinction must be made between the 'sun heat' or 'radiant heat' and the 'air heat' or 'shade temperature'. Radiant heat is the heat directly radiated from the sun which warms the human body and other solid and liquid objects on which it falls; but it has very little power in warming the air through which it passes. Shade temperature is the result of emanation of heat which the sun's rays have imparted to the surface of the earth. In sea coast regions the temperature is influenced by the ocean and the difference between the hot and cold seasons is less marked, and the climate is known as *equable.* In mountainous regions the altitude diminishes the mean annual range of temperature. The climate of inland places is rather variable, being extremely cold in winter and very hot in summer. In addition to these seasonal variations, fluctuations of temperature occur almost daily. This is less marked in places with a constant temperature and in sea coast climates, and more marked in inland and temperate climates.

---

* *Climate and Acclimatisation :* Green's Encyclopœdia of Medicine. Vol. II.

Influence of Temperature on Health.—It has been observed that the most vigorous races are produced in places where the temperature is changeable and the difference between hot and cold seasons is great. On the other hand, weak and languid races of men are to be seen in places having equable temperature. High shade temperature is less tolerated than the same degree of sun heat.

The high temperature of the tropics causes certain important changes on European constitution. There is an increased peripheral circulation with a greater activity of the functions of the skin causing profuse perspiration, which in its turn keeps the body temperature normal. This adjustment of the system to counteract the external heat is not often sufficient to a new comer and the body temperature ramains slightly higher than normal. Owing to the increased supply of blood to the surface of the body the capacity of the lungs increases, and as much as twenty three ounces of blood have been withdrawn from the lungs with a temperature of 80° to 83° F. The number of respiration is diminished, and the fact that hot and rarefied air contains comparatively less oxygen, the intake of oxygen with the inspiration and the output of CO_2 with the expiration is also lessened. This diminished excretion of carbonaceous products is compensated by the increased functional activity of the liver, skin, bowels and spleen. On the whole the general effect is that of diminished vital activity: the heart is weakened with slowing of the pulse, digestion is impaired, appetite lessened and nutrition interfered with, as evidenced by loss of weight and diminished bodily activity. Apart from diseases caused by parasites, microbes and other unhealthy conditions, nervous disorders and internal congestion may be traced to the climatic conditions of the tropics. Thus, the effect of heat on the system may be either direct or indirect. Directly it may cause diseases like sunstroke or fever, or might interfere with or suspend some of the most important and natural functions of the body. Indirectly it may produce heat syncope or asphyxia, deterioration of the blood and congestive disorders affecting the liver and bowels.

Effects of Cold on Health.—The effects of cold are opposite to that of heat. Long continued exposure to extreme cold causes contraction of arterioles, especially of the extremities, leading to chilblains, gangrene and coma. Ill-fed men are more susceptible to the action of cold. Whatever might be the temperature or thermometric readings, cold and its ill effects are not uncommon in India. The cold season in Calcutta is very pleasant and invigorating to those enjoying sound health, but to many, at least at its beginning, it gives rise to chill and internal congestion. The cold checks the superficial circulation and perspiration rather suddenly. Of all the vicissitudes to which the climate of India is liable, none interfere with health so seriously as the rapid transitions of its temperature do. The common ill effects of the sudden transition of temperature are acute hepatitis, colic, acute diarrhœa, or dysentery. When a person in hot season leaves the plains for the hills, where the ascent is sudden, a rise of a few hundred feet accelerates the heart's action, checks perspiration and causes profuse dieuresis, or he might get a sharp attack of diarrhœa indicating that the liver and intestinal mucous membranes are acting vicariously for the skin.

Effects of Humidity on Health.—A certain amount of moisture is always present in the atmosphere, and climates have been classified into *moist* and *dry* according to the degree of humidity. The degree of dryness or moisture of the air is expressed in terms of relative and not of absolute humidity. The amount of moisture in the air increases with the rise of temperature. At freezing point the air contains two grains of water vapour, whereas it contains eight grains at 70° F. It follows therefore that air which is damp at a low temperature or saturated with moisture becomes dry when the temperature is raised, even though the absolute quantity of moisture remains unaltered. Temperature has therefore a great bearing upon the moisture of the air, and the presence of water vapour in the air often moderates the heat of the sun, which however lessens radiation of heat from the ground. Similarly, by regulating the distribution of temperature, and reducing its daily variation within a small compass, the humidity makes the climate of a place more equable.

Excessive humidity retards evaporation from the lungs and skin in as much as the atmosphere being very liberally charged with moisture exerts little or no drying effect. The evaporation of moisture by which the cooling of a body is effected causes a certain amount of heat to become latent. When moisture is combined with heat, it becomes very oppressive although not so trying when combined with extreme cold. Moist climate is less healthy than dry ones, as moist air favours growth and development of micro-organisms. Putrefactive changes take place more readily in moisture than in dryness.

Effects of Atmospheric Pressure on Health.—The atmospheric pressure is an important factor of climate. It varies according to altitude and movement of the air. Its influence on health may be considered under the two following heads: (1) the effects of diminished pressure, and (2) the effects of increased pressure.

1. *Effects of Diminished Pressure.*—760 mm. (30 inches) of mercury or a weight of 15 pounds on every square inch is the pressure of air at the sea level. At high altitude the pressure diminishes on account of the rarefaction of the air; roughly, an ascent of 1800 feet takes off one pound; about one-eighth of the atmospheric pressure is lost at 2500 feet, a sixth at 5000, a quarter at 7500 and about one-half at 16000. For an ascent of 300 feet the temperature is reduced by 1°F. The weight of oxygen in a cubic feet of air is also diminished in proportion to the diminution of pressure. Diminished pressure has certain physiological effects on the system as is evidenced by increased rapidity of the pulse and frequency of the respiration, which also becomes deeper and fuller. Consequently mountain tribes have well-developed chests with strong heart and vascular system.

The physiological effects of diminished pressure can be perceived at a height of 6000 or 7000 feet; they are increased frequency of the actions of the heart, lungs and kidneys, as well as increased evaporation from the skin and lungs.

Persons suffering from valvular diseases of the heart, affections of the kidneys and liver, dysentery, diarrhœa, rheumatism, chronic bronchitis, &c., fare badly in high altitudes.

2. *Effects of Increased Pressure.*—Increased pressure of air produces effects of a very opposite nature, but the system soon accommodates itself to this altered condition. The effects are best observed in persons working in diving-bells, compressed air chambers (caissons), &c. The group of symptoms produced under such conditions are generally known as "caisson disease." A caisson is an iron cylinder sunk in a river bed so as to form a shaft into which air is pumped under pressure after closing the top, when the water is forced out through the lower end of the shaft.

CLASSIFICATION OF CLIMATES.

For purposes of division originally three great climatic conditions were described :

(1) The hot or warm climate with a mean annual temperature of 80° F.,

(2) the temperate climate with 60° F., and

(3) the cold climate with 40° F.

A more scientific division is made by using iso-thermal lines, as very often the regions occupying the same latitude give different annual temperatures.

For practical purposes the climate is divided into : (1) cold, (2) temperate, (3) warm, (4) mountain, and (5) marine and oceanic.

(1) *Cold Climates.*—These belong to regions lying between the poles and 50° of latitude. Here the winter is severe and prolonged, and the summer is very short. The mean annual temperature varies from 50° F. to 40° F., or may be even below the freezing point. Rain is comparatively absent, but there is abundance of snow. Although severe cold has a tiring effect on the lungs and kidneys yet according to some observers death rate in these regions is the lowest in the world. Severe cold makes the inhabitants vigorous

and muscular, and improves the power of digestion. But owing to the deficient growth of vegetables and the unhygienic condition of the people living in these regions they are very prone to suffer from scurvy ; further, their nervous systems are not so well developed.

(2) *Temperate Climates.*—The geographical limit is from 35° to 50° of latitude, and the mean annual temperature varies from 50° to 60° F. These are the healthiest climates upon the earth, and are inhabited by the most civilised and vigorous races of the world. Four well-defined seasons, usually most rainy during autumn and winter, are to be found here.

(3) *Warm Climates.*—These include regions lying between the equator and 35° of latitude on either side of it, and contain within their limits Southern Asia (including India and China), Polynesia, Africa with its islands, North America south of California, and South America north of Uruguay, with the West Indies. They are subdivided into *equatorial*, *tropical*, and *sub-tropical* climates. In the equatorial the maximum temperature is 118° F., the minimum 54° F., and the mean annual varies from 80° to 84° F. High temperature, heavy rainfall with well-defined dry and wet seasons are the characteristics of these regions. The heat is modified by rainfall which is rarely less than 40 inches annually and the difference between diurnal and nocturnal temperatures is slight. The common diseases attributed to warm climates are : insolation or sun stroke, cholera, yellow fever, dengue, liver abscess, small pox, dysentery diarrhœa, kala-azar, &c.

(4) *Mountain Climates.*—The characteristics of mountain climates are extreme heat and cold, greater purity and rarefaction of air, and diminished atmospheric pressure due to high altitude. Mountain climates are best suited to persons with a tendency to tuberculosis.

(5) *Marine and Oceanic Climates.*—The peculiar features of these climates are greater equability of temperature, and increased moisture and rainfall, as evidenced by the climates of small islands and places on the seacoast. The climates of Great Britain, Ceylon, and the coasts of India may be mentioned as examples. The good effects of sea air are ascribed to its great purity and the presence of ozone which has

a general tonic effect on the constitution. The variations of temperature between summer and winter, and between day and night, are less marked.

Effects of Vegetation and sheet of Water on Climate.

Vegetation in moderation improves the climate by keeping the air cool and equable, and counteracts the effects of radiation from the earth. The temperature of the sides and base of a hill is considerably raised if the slope is covered with trees which obstruct the downward current of air. Trees exert an attractive influence on the water-charged clouds and so rainfall and relative humidity are correspondingly increased. Thick trees and forests afford a protection from hot winds in tropical countries (see also page 72).

The deprivation or absence of vegetation, as in deserts or dry lands, leads to great variations of temperature. They are very hot during the day, and owing to the presence of dry air radiation is very rapid at night when the temperature falls down considerably.

The effect of ocean, lake or any large sheet of water is very great in affecting the climate of a place. The specific heat of water is four times greater than that of land, with the result that it takes a longer time for heating as well as for cooling. It follows, therefore, that the temperature of the atmosphere close to large sheets of water would remain uniform. Sea water freezes at a temperature of about 28° F. and fresh water at 32° F., consequently the sea remains open when the lake freezes; hence the sea exerts a greater influence in moderating winter cold and summer heat. Moreover, the currents by causing an admixture of water of different climates help the sea to moderate extremes of temperature.

METEOROLOGY.

Meteorology is the science concerned with the phenomena occuring in the atmosphere; while *weather* is the general condition of the air at any stated period or time, particularly of that portion of the air lying next to the earth's surface. In all meteorological observations the results obtained by different observers at different stations are recorded by instruments which must be similar in form and exposed in the same way. It is necessary also that all mistakes peculiar to these observations and to the observer must not be lost sight of. All observations must be systematically and accurately made and their results interpreted.

Meteorology of India is of special interest, presenting as it does a greater variety of meteorological conditions, actions, and features than any other place of similar size in the world. This is ascribed to (1) its variety and contrast, (2) the presence of a combination of tropical and temperate region conditions, and (3) its being an area of pronounced monsoon conditions. The principal climatic phenomena requiring systematic record are:—

I. The temperature of the atmosphere.
II. Atmospheric pressure.
III. Movement of wind.
IV. Humidity.
V. Presence of ozone.
VI. Sunshine or solar radiation.
VII. Atmospheric electricity.
VIII. Rainfall.
IX. Presence or absence of cloud, fog, mists and storms.

I. Temperature.

Next to rainfall temperature is the most important feature of meteorological observations. This is recorded by thermometers which are exposed in open sheds to allow a free circulation of air, and protected from the direct rays of the sun by a thick roof or thatch. In cold weather and during the hottest part of the day the temperature of the ground surface is about 10° to 20° higher than that of the air at four feet high, and this goes on increasing up to 40° or 50°. But this difference becomes less during the rains. The mean daily temperature, or simply temperature, is that obtained by adding twenty-four hourly observations and dividing by 24. The temperature of a month is the mean of those of thirty days, and the temperature of a year is the mean of those of twelve months.

The temperature of the air varies at different parts of the day. It is increased by the absorption of solar radiation during the day, and is affected during the whole diurnal period by radiation to clouds, &c. The variation of temperature with a maximum and minimum, dividing the day into periods of 8 and 16 hours is the *diurnal variation*, and the difference is the *diurnal range*. There is again what is called the *annual variation* of temperature; this is the regular increase in the temperature during one-half of the year succeeded by a decrease during the other half.

The temperature of the air of a particular place varies, and the principal causes which modify the temperature are: (1) latitude of the place, (2) height, (3) direction of wind, and (4) proximity of the sea. In the north-western parts of India and the northern parts of the Bombay Presidency the daily range of thermometer is very great during the months of October and November when the difference between the maximum and minimum temperature fluctuates between 30° and 35° F., while in the United Provinces it averages between 28° and 32°F. The amount of diurnal periodic change is less on sea than on land, and least on the sea-coast of the islands in the tropics. The amplitude of yearly fluctuation is less on sea than on land and is least in the tropical countries. In the most northernly part of India it averages 94°F., and in the Punjab it varies from 80° to 84°F.

The lines which connect places which have the same mean temperature are called *isothermal lines*; these mean temperatures may remain the same either for the year or for several months.

Thermometers.—Thermometers are instruments for measuring temperature. Liquids are by far the best suited for their construction, and mercury and alcohol are the fluids generally preferred. Mercury is used as it boils at a very high temperature, and because of its regular expansion; alcohol, on the other hand, has the advantage of not solidifying even at the lowest known temperature. Of these, mercurial thermometers are more widely used.

Maximum and Minimum Thermometers.—In meteorological observations the highest and the lowest temperatures in the 24 hours are often necessary, for which purpose these thermometers are used. They consist of a wooden board upon which two thermometers are fixed, the bulbs of which are bent at right angles and the stems are placed horizontally. The upper one contains mercury and indicates the maximum temperature, and the lower one is an alcohol thermometer. The mercurial one has an index of a short rod of glass or wood which moves freely in the tube. When the thermometer is placed horizontally the index is pushed with the rise of temperature and consequent expansion of mercury, but remains at the same place even after the mercury had contracted; thus registering the highest temperature of the day. In the alcohol one, the index is a dumble-shaped glass which is drawn by capillary attraction until it has reached the greatest contraction. But when the alcohol expands with the rise of temperature it passes between the sides of the tube and the index, and therefore does not displace it. It thus records the lowest temperature that has been reached.

Six's Thermometer.—It is a combination of maximum and minimum thermometers and gives double reading. It consists of a U-shaped glass tube with a bulb at each end, the middle portion of which contains mercury. Both the tubes above mercury and one bulb contain alcohol, and part of the other bulb contains alcohol vapour and air. In each stem there is an iron index which may be moved by a magnet. With the rise of the temperature the alcohol expands and pushes the mercury and with it the index well up the other stem. With the fall of the temperature the alcohol contracts and the mercury falls and with it pushes up the index in the other column. In this way the highest and the lowest temperatures are recorded by the indices in the right and left limb respectively.

Vacuum or Solar Radiation Thermometer.—This is a mercurial maximum self-registering instrument having a bulb coated with lamp black to absorb the sun's rays. The bulb is placed in a vacuum glass case in order to prevent the coating from being washed off by rain. The glass case also protects the bulb from loss of heat which would otherwise take place. The instrument is placed horizontally 4 feet above the ground, away from walls and trees, and exposed to the rays of the sun direct. The difference between the maxima in the sun and in the shade is the amount of solar radiation, or of the power of the rays of the sun.

A terrestrial thermometer is a minimum shade thermometer placed close to the ground with the bulb resting on the grass about 4 inches above the ground. If the grass plot cannot be had the thermometer should rest on a large black board placed upon the surface of the ground, or it should be laid on snow if the ground is so covered. The difference between this minimum temperature and the air minimum in the shade is the amount of terrestrial radiation.

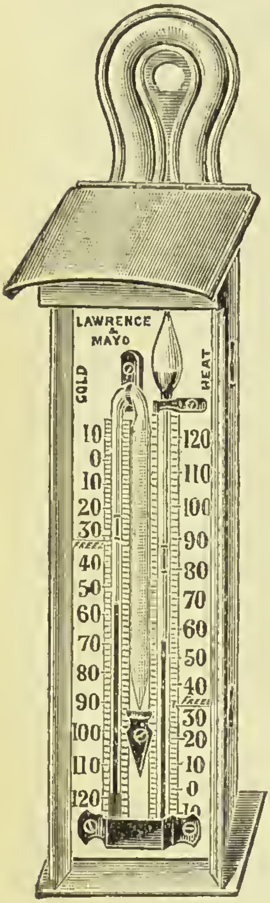

Fig. 19.

Six's Thermometer.

II. Atmospheric Pressure.

The atmospheric pressure is determined by means of a *barometer*. It may be either mercurial, glycerine, water, or anæroid barometer; mercury being the heaviest known liquid is generally selected. A mercurial barometer consists of a glass tube (about 33 inches long), closed at one end, filled with mercury and inverted into a trough or cistern also filled with mercury. The pressure of the atmosphere at the sea level on the surface of the mercury in the trough supports the mercury in the tube to a height of about 30 inches. The mercury in the tube will fall when the pressure is diminished as in mountain ascent, and will rise with the increase.

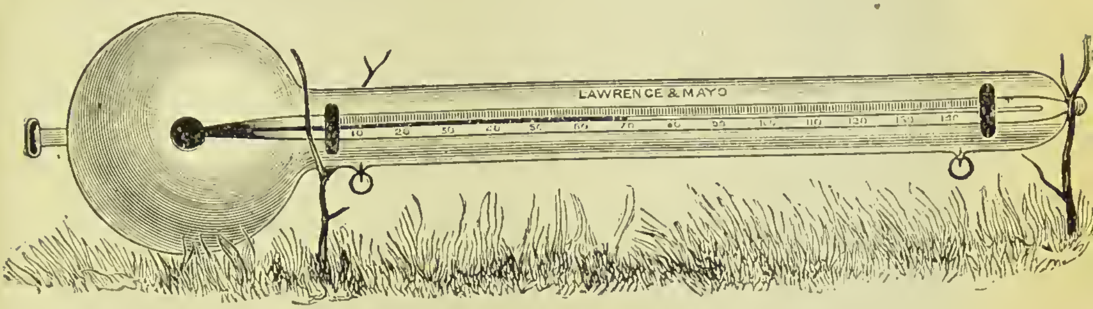

Fig. 20.

Vacuum or Solar Radiation Thermometer.

In order to obtain a greater accuracy **Fortin's standard barometer** (Fig. 21) is now used. In this the cistern is made with a pliable base of leather which can be raised or lowered by means of a screw. The upper portion of the cistern is made of glass through which the zero of the scale can be seen as a piece of ivory, the lower end of which is called the *fiducial point.* Before taking a reading the level of the mercury in the cistern must be so adjusted as to correspond to this point, which is the zero of the scale, by means of the screw. To obtain a more accurate reading a sliding scale of Vernier is attached. The Vernier is so graduated that 25 of its divisions correspond to 24 half-tenth divisions on the barometer scale. Therefore each division on the Vernier is $\frac{1}{25}$th less than a half-tenth division on the barometer scale, and is therefore $\frac{1}{25}$th of $\frac{1}{20}$inch ($=\frac{1}{500}$ or 0·002 inch).

Method of reading Fortin's Barometer.—Adjust the Vernier by means of the rack and pinion at the side of the barometer so as to bring its two lower edges on a level with the convex surface of the mercury and count the number of divisions on the Vernier from below upwards until a line on the vernier is exactly continuous with a line on the barometer scale. Multiply the number on the vernier so obtained by ·002 and the product is the number in thousands of an inch.

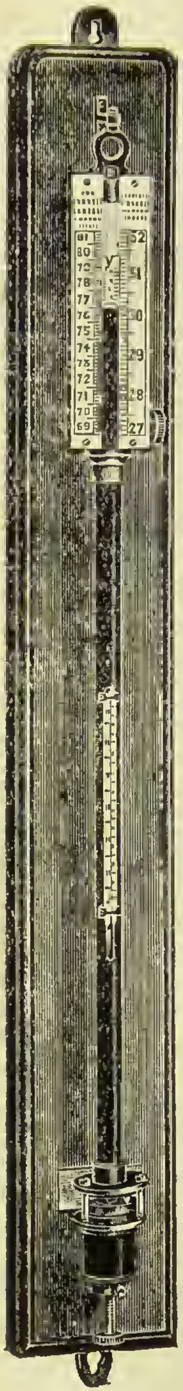

Fig. 21.

The barometer must be properly fixed in a well lighted room and protected from the sun, rain and wind. Corrections must be made by Glaisher's tables for temperature above 32°F., as mercury expands with the rise of temperature. If observations are taken at an altitude an allowance for about $\frac{1}{1000}$th inch for every foot of ascent above the sea level must be made.

Anæroid Barometers.—These are so-called as no fluid enters into their construction. They are small watch shaped metallic vacuum boxes. The box is closed by a metal lid which being elastic is acted on by changes in the atmospheric pressure. By an arrangement of levers the movements of the metal are made to turn an index and are recorded on a dial. This instrument is mainly used for recording altitudes and it is customary to read the nearest $\frac{1}{100}$th of an inch both before and after an ascent and then to deduct one reading from the other without taking into consideration the decimal points and multiply the difference by 9. The product is the height above sea-level in feet.

Barometeric Fluctuations.—These may occur from variations in the atmospheric pressure which may be regular or irregular. The former is diurnal or annual, while the latter is cyclonic or anticyclonic. A fall in the barometer indicates either that the air is hot or that it is highly moist. Moreover, the pressure falls when the air, as in certain varieties of winds, moves upwards. On the other hand, a rise in the barometer shows that the air is either cold, or dense, or dry. Diurnal fluctuations are best observed in the tropics where the average range is about $\frac{1}{10}$th of an inch ; the maximum occuring at 9 A.M., and again at 9 or 10 P.M.

The *annual variations* are in considerable excess than the diurnal ranges. In the Equatorial region where the temperature and moisture remain almost constant throughout the year, the variation in the mean pressure is slight. The average pressure in Calcutta during July is 29·538 inches and in January 30·022 inches, thus giving a difference of 0·484 inch. This is due to very great heat in July coupled with the heavy rains accompanying the south-west monsoon.

The changes in weather over a wide area brought on by daily, monthly, and annual irregular variations of the barometric pressure are principally divided into *anticyclonic*, if the weather is good, and *cyclonic* if the weather is bad. Now-a-days barometric readings at a given time over an extended area are telegraphed to a central station to be recorded. If observations of stations having the same barometric pressure are recorded on a map we get a *synoptic map*, and the lines connecting such places or stations are called *isobars*, which arrange themselves in certain typical forms associated with certain kinds of weather. There are seven different kinds of isobars, *viz.*, (1) cyclone, (2) secondary cyclones, (3) anti-cyclone, (4) V-shaped depression, (5) wedge-shaped isobars, (6) cols, and (7) straight isobars.

III. Movement of Wind.

Wind is the effect of disturbances of equilibrium constantly proceeding in the freely mobile atmosphere ; the causes of these disturbances being differences in atmospheric pressure brought about by changes in temperature and moisture, aided by physical and other factors. Winds carry with them the temperature of air they have traversed, while the amount of moisture which they can hold increases with the temperature. In all parts of the world the lower current of air moves slowly than the upper. During the day the lower strata on being heated ascends increasing the friction between the upper and lower currents and reducing the velocity. On the surface of the earth near the Equator and all over the sea there is little or no diurnal variation either in direction or speed. On the plains or on high altitudes the wind moves with the hands of a clock, and attains its maximum strength during the afternoon, backing and diminishing again at night in the northern hemisphere (Notter and Firth). On mountain peaks the wind moves against the hands of a clock, the maximum being attained at night.

The primary factor in the meteorology of India is alteration of seasons. The north-east and south-west trade winds are set in motion by the movement of the earth and are due to the incessant movement of cold air from the poles, replacing the heated air of the tropics. The south-west and north-east monsoons are seasonal. The south-west monsoon is a season of winds of oceanic origin of high humidity and of frequent and heavy rains over nearly the whole of India. The north-east monsoon, on the other hand, is of continental origin, and is therefore dry except where they have travelled over some sea. Hence the north-east monsoon in India is characterised by clear lightly clouded skies with occasional rain. These are therefore more appropriately termed *wet* and *dry* monsoons, suggesting as they do the most important and prominent features of the seasons in the land area of India. In fact about 90 per cent of the annual rainfall of India occurs during the south-west monsoon. The dry monsoon is again divided into two periods—one of comparatively low and the other of increasing and high temperature. The wet monsoon is similarly subdivided into two periods—June to September is the *monsoon proper* while October to December is called the *retreating* monsoon. During the cold weather period India is characterised by clear sky, fine weather, large diurnal range of temperature and light land winds. The months of November and December are the pleasantest of the year in Northern India.

Anemometer.—The pressure and velocity of wind is recorded by instruments called anemometers of which there are several kinds, Robinson's wind anemometer being considered the best. It consists of a metal cross provided with hollow hemispherical cups at their ends, and revolving horizontally on a vertical axis which by an arrangement of a screw records the movements on the dial. From the number of turns made in a given time the velocity of the wind is deduced.

The cups move at a rate equal to only one-third that of the wind, and allowance is therefore made for graduating the instrument. The instrument should be kept clean and properly oiled, and fixed at least 20 feet from the ground.

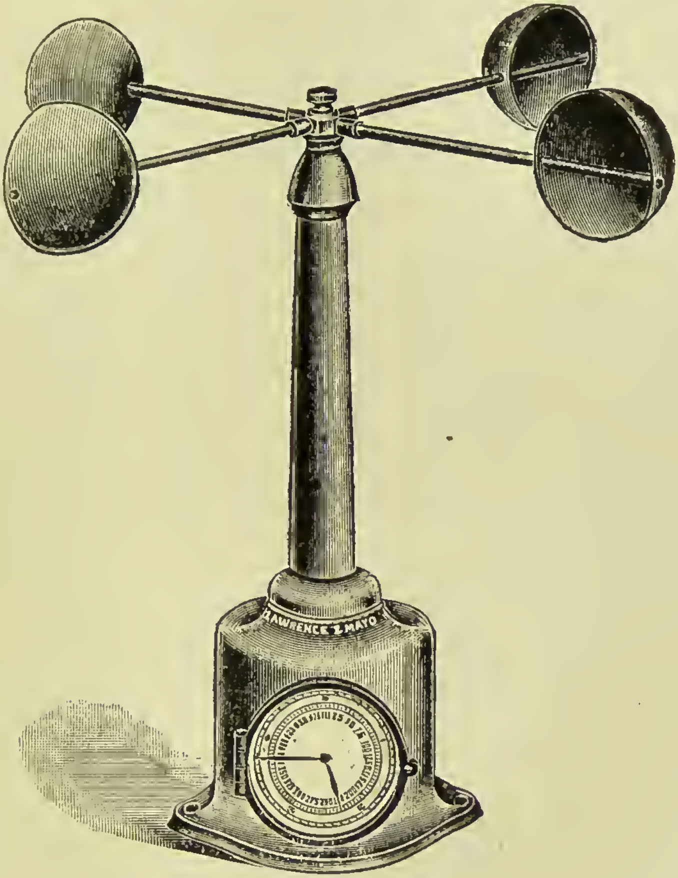

Fig. 22,
Anemometer.

IV. Atmospheric Humidity.

Water is being constantly evaporated into the air, and the amount of moisture which the air can hold varies with the temperature. The atmosphere is more or less charged with aqueous vapour and the amount of moisture which the air can hold varies considerably not only with the temperature but with the season, and with the elevation and position. During the height of the wet monsoon, it is about 10 to 12 grains per cubic foot in the coast districts of Bengal and Bombay. It is usual to speak of the amount of moisture present in the air as the *degree of humidity.* The amount of moisture present in a given volume of air is called *absolute* humidity, whereas *relative* humidity indicates the percentage of the amount of moisture that is required to cause saturation. If the saturated air be cooled down it will reach a temperature at which the moisture will condense and fall on the earth as rain, hail, mist or dew. The precipitation of moisture on the surface of the earth or on grass, leaves, &c., is called *dew*, and is formed by the air coming in contact with the cold surface of the earth at night and parting with its moisture from loss of temperature. When the temperature rises again the dew disappears, and the mean of the temperatures of appearance and disappearance is the *dew point.* Dew point is determined by means of a hygrometer, and is roughly calculated by means of a dry and wet bulb thermometer. Glaisher's method gives more accurate results.

Air is usually drier during summer than in winter, and during day than at night. The moisture of the air is as a rule invisible. Absolute humidity is higher in summer than in winter and varies with the movements of the air, the conditions of the sky, and the nature of the climate.

Relative Humidity.—This is merely a convenient term used to express comparative dryness or moisture. Complete saturation being assumed to be 100, any degree of dryness may be expressed as a percentage of this, and is obtained at once by dividing the weight of vapour actually existing by the weight of vapour which would have been present had the air been saturated. In other words, the hygrometric state or relative humidity (H) may be expressed as the ratio of the elastic force of aqueous vapour at the temperature of the air (E) to the elastic force of the vapour at the temperature of the dew point (*e*) ; that is $H = \frac{e}{E} \times 100$.—(Notter and Firth). In Calcutta the relative humidity is 80 to 93.

Hygrometers.—The amount of moisture present in the air is registered by *hygrometer*, of which there are two kinds, *viz.*, the *direct* and the *indirect* hygrometers.

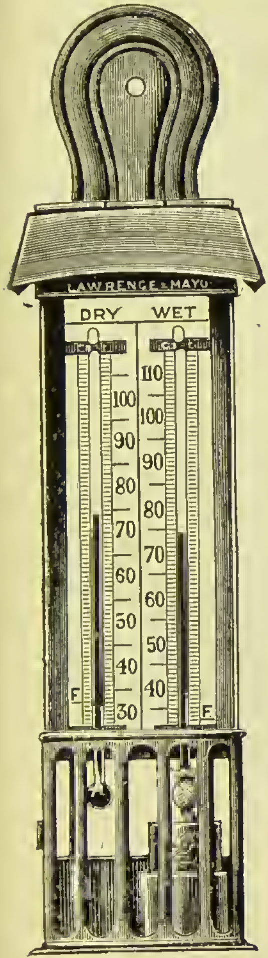

Fig. 23.

Wet and dry bulb Thermometer.

Daniell's Hygrometer.—This consists of a glass tube bent twice with a bulb at each end, one being placed at a lower level than the other. The lower bulb is partly filled with ether and a thermometer dips in it. The other bulb as well as the remaining portion of the tube contains ether vapour. The empty bulb is covered with muslin which is kept moist with ether. The ether in evaporating cools the bulb and the loss of temperature so brought about condenses the ether vapour inside the bulb and tube, which in its turn causes an evaporation of the ether inside the lower bulb. Thus the lower bulb cools down and reduces the temperature of the air around it until it becomes so low that it forces the air to part with some of its moisture which condenses upon the surface of the bulb. As soon as this happens the temperature from the attached thermometer is read off and recorded as the dew point.

Wet and Dry Bulb Hygrometer.—This instrument consists of two thermometers mounted side by side on a stand, and is used to determine the pressure of the aqueous vapour in the air. The wet bulb is kept constantly moist by means of a piece of muslin wrapped round it and dipping into a small vessel of water. The water in evaporating absorbs heat from the thermometer with the result that the temperature indicated by this thermometer is much below than that given by the dry one. The difference in the two thermometers however depends on the rapidity with which the evaporation proceeds, and the rate of evaporation depends on the temperature and humidity present. In dry air evaporation being rapid heat will be absorbed from the thermometer at a greater rate and the temperature of the wet bulb will be much below that of the dry one. The instrument should be kept in the shade and protected from air currents and direct sunshine.

V. ATMOSPHERIC OZONE.

It is popularly believed that the presence of ozone in the air is more conducive to health, but this requires further confirmation. Potassium Iodide and starch papers are used for the detection of the presence of ozone in the air, but they are not reliable as other substances especially nitrous acid turn them blue.

VI. SUNSHINE.

The duration of sunshine influences the climate to a great extent and is recorded by means of Campbell-Stokes sunshine recorder. It consists of a glass sphere on which the rays fall and the image is received on a strip of millboard at the proper focal distance. When the sun shines the rays are focussed upon the millboard or on some sensitive paper leaving a record or a mark behind. But this does not occur when the sun sets or is hidden by clouds. The results are best expressed in percentage of sunshine, *i.e.*, if the sun is above the horizon for eight hours and the record is but 2 hours, the sunshine equals 25 per cent of the possible amount.

VII. ATMOSPHERIC ELECTRICITY.

The atmosphere is always charged with electricity, and many hypotheses have been propounded to explain its presence. It has been ascribed to (1) growth of vegetation, (2) evaporation of water containing salts in solution, (3) friction of the air against the ground, and (4) combustion. The fact-that powerful atmospheric phenomena are accompanied by rain and hail seems to suggest a connexion between the excitation of electricity and condensation of aqueous vapour. It will be seen that in volcanic outbursts large masses

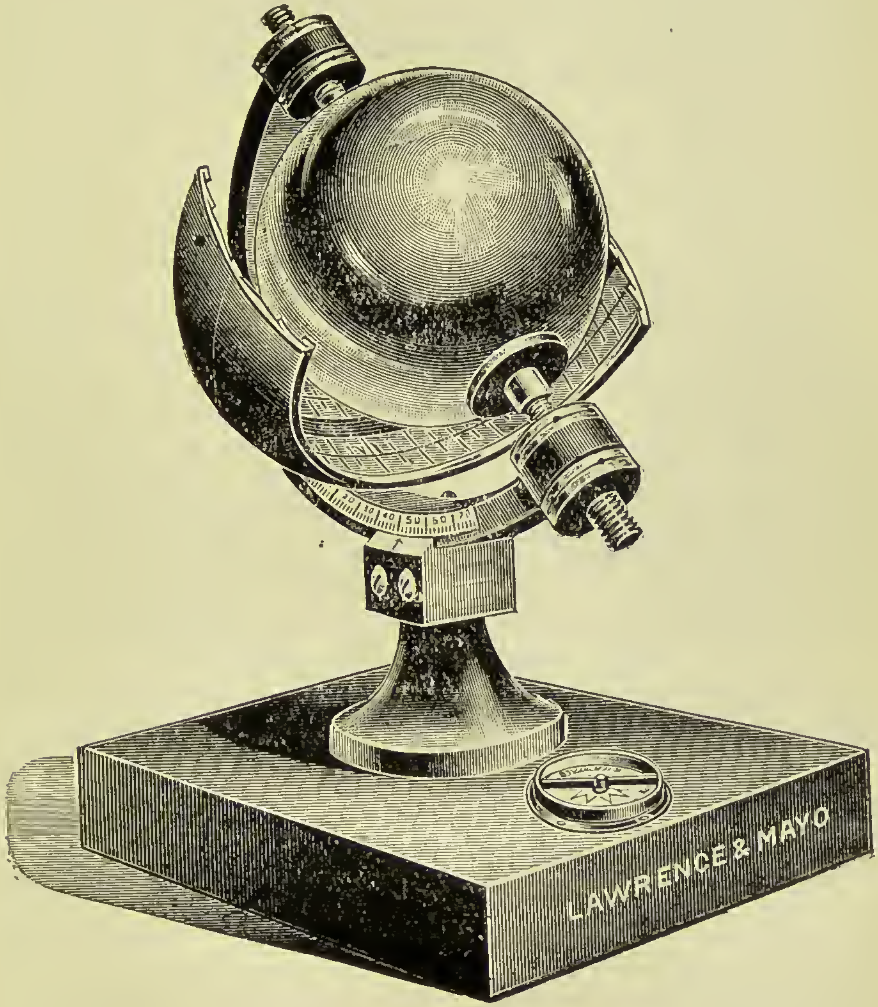

Fig. 24.

Sunshine Recorder.

of aqueous vapour ascend and condense at a height forming large clouds, which after sending forth lightning flashes and thunder is resolved into rain. When the sky is cloudy the electricity is sometimes positive and sometimes negative. It is nearly always positive in a fine weather. The electricity of the ground is always negative but differs with the humidity and temperature of the air.

VIII. RAINFALL.

When the temperature of the air charged with moisture is suddenly reduced either by its ascent in the higher and colder regions or by coming in contact with a cold surface as the ridge of a mountain, or a colder surface of the earth, or a large sheet of water condensation of the vapour takes place. By constant condensation of aqueous vapour these minute particles of vapour become larger and heavier and uniting form regular drops which fall as *rain*. Rain drops are very small when high up but from their low temperature they condense on their surface the aqueous vapour of the layers of the air through which they fall and become larger. The amount of rain which falls in different countries varies with the local circumstances, and other things being equal, most rain falls in the tropical countries where evaporation is abundant; in fact rainfall diminishes from the equator to the poles. Under similar conditions the quantity of rain decreases with the distance from the sea and increases with the height above sea level, for mountains produce rain when they arrest a current of moist air. Actual data show that in the Western Ghauts the rainfall is on the average at least three times as great on the crest of the hills as at sea level. The average rainfall during the south west monsoon in the coast districts of the Konkan is about 100 inches and increases up to about 300 inches on the summit of the hills at an elevation of 3000 to 4000 feet. Sylhet at the foot of the Assam hills has an average total of 157 inches, while Cheerapoonjee on the Assam hills at an elevation of about 4000 feet has an average of 458 inches. The following is a statement of mean or normal rainfall in India derived from the average of about 2000 stations distributed over the whole country :[*]

Cold weather (January to February)	0·99	inches.
Hot weather (March to May)	4·58	,,
S. W. monsoon (June to September)	34·65	,,
Retreating S. W. monsoon (Oct. to Dec.)	4·95	,,

It appears that of the mean annual rainfall 12 per cent occurs during the dry and 88 per cent during the wet season, but the ratio differs in different parts of India, varying for the dry season from 3 per cent in Bombay to 19 per cent in Bengal, 21 per cent in the Punjab and 30 per cent in Assam.

The rainfall during the cold weather is due chiefly to disturbance in condensation in an upper current. It is very irregular in its occurrence but the normal amount differs but slightly over the plains and varies from half to one inch, except in the Punjab and Assam where it averages two inches. The cold weather rainfall, small though it may be, is nevertheless of great economic value especially over the large part of northern and central India, as upon it the winter crops of non-irrigated districts depend.

Hot weather rainfall presents much greater contrast. This rainfall is often accompanied by dust storms and is small in amount averaging only about one inch accompanied by thunder storms of great violence and intensity especially in Assam, Bengal, Arrakan, Lower and Upper Burmah. It is of great value for the tea crops in Assam where it averages 31 inches, and in Bengal it favours the early spring crops of rice.

Rainfall is measured by a *rain-gauge* which consists of a copper funnel leading to a receiver. The funnel has a sharp rim and is usually five inches in diameter. The rain having been collected into the receiver is measured in a glass vessel graduated to correspond with $\frac{1}{100}$th of an inch of rainfall. The reading is generally taken at 9 A. M. daily, and the instrument placed on the ground in an open place with the rim about one foot above the earth. In time of snow, melt the collected snow by adding a known quantity of warm water to it, and the extra water derived from snow is counted as rain water. Roughly, one foot of snow may be taken to represent an inch of rain.

---

[*] Imperial Gazetteer of India.

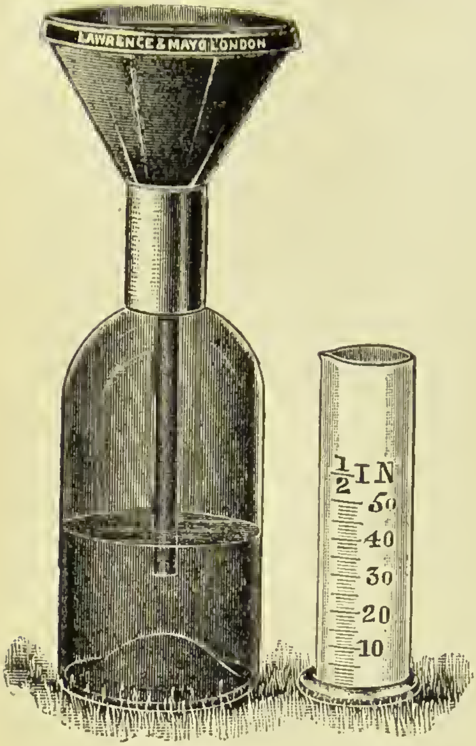

Fig. 25.

Rain Gauge.

IX. Clouds.

A *cloud* may be defined as a mass of vapour condensed into minute water particles which float in the air, differing from mists and fogs in occupying the higher regions of the atmosphere. A cloud is therefore a fog at a greater height. A *cloud line* is the level below which the formation of cloud rarely takes place. Clouds have been classified by Hildebransson and Abercromby as follows :

A. Highest clouds, mean height 9000 metres.
  (*a*) 1. Cirrus.
  (*b*) 2. Cirro-stratus.

B. Clouds of mean altitude, 3000-7000 metres.
  3. Cirro-cumulus.
  (*a*) 4. Alto-cumulus.
  (*b*) 5. Alto-stratus.

C. Low clouds, below 2000 metres.

(*a*) 6. Strato-cumulus.
(*b*) 7. Nimbus.

D. Clouds formed by diurnal ascending currents.

8. Cumulus. Top, 1800 metres ; base, 1400 metres.

9. Cumulo-nimbus. Top, 3000-8000 metres; base, 1400 metres.

E. Elevated fog, below 1000 metres.

10. Stratus.

Those marked (*a*) are detached or rounded forms, most frequently seen in dry weather ; those marked (*b*) are wide-spread or veil-like forms most frequent in wet weather.

CHAPTER XVII.

INFECTION AND CARRIERS OF INFECTION.

By *infection* is understood the introduction into the body, without contact with the patient, of some pathogenic micro-organisms which are capable of multiplying within it. Diseases therefore depending on such an infection are known as "infective" or "infectious" diseases. By *contagion* the disease is produced by actual contact with the person suffering from the disease. Although it is customary to draw a line of demarcation between infection and contagion, broadly speaking they are much the same, and according to the modern sense of the term the so-called contagious diseases are infectious. All diseases depending on the entrance of a living organism may more conveniently be classed as infectious.

Infection may be *general* or *local.* In tetanus and diphtheria, the organisms after infection cause some local disturbance and cannot be detected in the circulation. In enteric fever, the germs are present in the general circulation. In both instances, however, the constitutional changes are due to the toxins and not to the germs themselves.

Some persons are peculiarly susceptible to certain diseases, others offer some resistance to infection. This susceptibility is called *predisposition*, which may be natural, artificial or acquired, and the resistance as opposed to predisposition is known as *immunity.* It must be observed that susceptibility of the tissues varies greatly, and that infection or invasion of the body by bacteria does not occur every time the body is exposed.

Certain terms are used to express the relative prevalence of infective diseases ; they are : (*a*) *Epidemic*—when a number of cases break out by infection from a common source at one time and is then followed by a period of rest. (*b*) *Endemic*—when a disease is constantly present in a certain district. (*c*) *Sporadic*—when a disease occurs only in isolated cases. (*d*) *Pandemic*—when the epidemic is spread over a large area or over the whole world.

Incubation.—The characteristic feature of an infection is that the disease runs a definite course. After infection the germ remains latent, and the person does not develop any symptoms for a time. This latent period is called the "stage of incubation." The duration of this period varies, each case differing from every other, and depends partly on the amount of poison entering the system at the time of infection and also on the resistance offered by the individual. During this period the patient may remain perfectly healthy or may feel a little malaise. It has been shown that in typhoid and cholera the specific bacilli continue to be discharged from the body for a much longer time than is ordinarily supposed. During this incubation period a person exposed to an infection requires to be isolated or placed in quarantine. It is of great value in considering the measures for the suppression of infectious diseases.

The following table gives an approximate statement of the period of incubation and the duration of the communicability of some of the most important microbic diseases :

Disease.	Incubation period.	Infective period.
Chicken pox ...	10 to 12 days	3 weeks.
Cholera ...	a few hours to 5 days	2 ,,
Dengue ...	3 to 6 days	2 ,,
Diphtheria ...	1 to 8 ,,	6 ,,
Enteric Fever ...	5 to 20 ,,	6 ,,
Influenza ...	1 to 4 ,,	2 ,,
Measles ...	8 to 15 ,,	4 ,,
Mumps ...	12 to 22 ,,	3 ,,
Plague ...	3 to 10 ,,	3 ,,
Small pox ...	12 ,,	6 ,,
Whooping Cough	4 to 14 ,,	8 ,,

Bacteria.—Bacteria are micro-organisms which are the active causes of infective diseases. Some of them are motile while others are not. They are very minute organisms measuring not more than $\frac{1}{25000}$th inch in width. They have been classed into three main groups according to their shape :

(i) Cocci—when of rounded shape.
(ii) Bacilli—when rod-shaped.
(iii) Spirilla—when curved or spiral.

According to whether bacteria thrive upon living or dead matter as well as according to their most characteristic effects they have been classified for the sake of convenience into *Zymogenic* (fermentative), *Aerogenic* (gas producing), *Saprogenic* (putrefactive), *toxicogenic* (poison-producing) and *pathogenic* (disease producing) organisms. According to whether the organisms grow in the presence or absence of oxygen they are classed as *aerobes* and *anærobes.* Some are *facultative, i.e.*, capable of multiplying under either one or the other conditions. Some bacteria are harmless both to animals and plants, and apparently under no circumstances give rise to disease in either. These are known as *saprophytes.* Others again live on the bodies of plants or animals and produce disease ; these are known as *parasitic* or *pathogenic* bacteria.

Each bacteria has the property when introduced into the body of manufacturing toxins peculiar to itself, and the distinguishing symptoms of a disease are due more to the toxins than to the presence of the bacillus itself. How the toxin is produced is a debatable point. Some hold that it is formed from the cell-plasma of the bacillus, others regard it as the product of the action of the bacillus on the proteid substances. The functions of the body may therefore be disturbed by the bacteria in two ways : (1) through the absorption of their excreted toxins or by the changes wrought on the proteids by these toxins (simple intoxication, as in cholera), (2) by their growth and the production of toxins within the body (infection, as in typhoid fever).

Modes of Infection.—Micro-organisms may be introduced into the human body in a variety of ways : inoculation, inhalation, ingestion, absorption and insects.

(1) *Inoculation.*—Generally the contagia of glanders, anthrax, vaccinia, tetanus and rabies are thus received. Abrasion facilitates infection from syphilis, gonorrhœa, &c.

(2) *Inhalation.*—This is the most frequent means of infection. Tubercle bacilli are generally carried through the air; similarly dry enteric germs may be disseminated through dust.

(3) *Ingestion.*—Water or food when contaminated often carries infection and causes epidemic outbreaks. Enteric fever, cholera and dysentery are as a rule produced through infection of milk, water or other food.

(4) *Absorption.*—This happens with mucous surfaces as in venereal diseases. In diphtheria the microbe is arrested in the nasal or pharyngial mucous membrane.

(5) INSECTS.

Sir Ronald Ross in his valuable work on mosquitoes first drew attention to the important part insects play in the transmission of diseases. Malaria, enteric fever, yellow fever, plague, filariasis, sleeping sickness, kala-azar, &c., are all caused through the agency of insects.

The size of insects varies from $\frac{1}{50}$th to 6 inches and they live from a few days to as long as over ten years, but rarely they live more than three years, and in majority of them the active lives are limited to only three months. They live wherever nutriment is available, on land as also in fresh water, and even in the bodies of warm-blooded animals and man.

Insects are intimately related to man; except perhaps the domestic animals no single group of animal life enters more into the daily life of man than insects. "They live on us and around us; in our food, our clothes, our furniture, our houses; we eat them or their products, we collect them and sew them on our clothing." There are insects that are useful, but there are many that affect man in other ways. "Think of one's daily life! There are cockroaches that smell, fish insects that eat our papers, ants that carry off our sugar, 'gundies' and other smelly things that flavour our food when they fall in, wasps and hornets that sting, mosquitoes that bite and annoy, to say nothing of sand flies, that no mosquito-net keeps out, and the bug and flea which continually pester us, the mudwasp that build nests in our books and close our locks ; furniture beetles that wear out our chairs, the cheroot beetles that spoil our cigars ; the book beetle that tunnels in our books, the moth that destroys our clothes. Daily and hourly we come in direct contact with insect life."*

The role played by ticks, biting flies and other blood sucking parasites in the transmission of various diseases to mammalia is one of economic importance. The malarial mosquito, a constant scourge of tropical and semi-tropical countries, has been shown to be a factor in the life history of great nations. The plague flea has taken its toll of millions from the human race. Africa, the greatest of all the continents, lies under the ban of trypanosome transmitting biting flies such as the tse-tses. Over half a million human beings have died during the last ten years from fly-borne sleeping sickness, whilst examination of a large number of villages by competent observers has shown that 30 to 50 per cent of the inhabitants in these infected areas must sooner or later succumb to this disease. Thus it will be seen that these invertebrate parasites affect the economics of the present and succeeding generations profoundly.†

The ways or means in which the insects may carry germs of disease from one place to another are to be carefully considered. They may act as *passive agents* : may simply convey the infection on their contaminated bodies or in their excreta. This transmission is purely mechanical and it is immaterial by which kind of insect it is effected. But the chief interest centres at the present time on the part the blood sucking insects play in the propagation of different parasitic diseases. It will be observed that parasites can infect a healthy animal only by direct inoculation, and in the absence of blood-sucking insects it is difficult to understand how this can very often occur. A blood-sucking insect therefore affords a ready means of introducing blood-parasite from one animal into another. But it is still debated whether the parasite is carried from one animal to another in a simple "mechanical" way undergoing no change *en route*, or whether as in the case of anophelene mosquitoes the parasite undergoes a series of changes before it is in a fit state again to infect a healthy animal's blood.

---

* Lefroy : Indian Insect Life.

† Carter : Bombay Medical Congress, 1909.

The blood sucking species of insects belong exclusively to two orders, *Diptera* to which belong the mosquitoes, sandflies, midges and the house flies, and *Rhinochota* to which belong the bugs and the lice. The face mite, itch insects and the tick, although strictly speaking cannot be classed as insects and are known as *Arachnida*, are also of interest to us in as much as they act as agents in transmitting certain diseases. Ticks are responsible for the propagation of relapsing fever.

General Characters of Insects.—The bodies of insects are covered with a tough skin and divided into three distinct parts : the head provided with two antennæ or horns, and eyes and mouth of variable form : the trunk or thorax composed of three segments which has underneath it always six articulated limbs, and often above it two or four wings : and an abdomen composed of nine segments some of which may be difficult to recognise. In addition to these characteristics they are not provided with interior skeletons and their nervous system is formed of a double cord, swelling at intervals, and placed under the head and along the underside of the body. Insects are not provided with lungs but breathe by particular organs termed tracheæ, extending parallel to each other along each side of the body, and communicating with the exterior air by lateral openings called *spiracles.* The sexes of all insects are distinct and are reproduced from eggs. (Lukis and Blackham).

The following is a list of insects classified by Balfour and Archibald and the diseases they are known, or supposed, to transfer.

1. *Ants :*—These insects may readily convey all the diseases due to contamination of food, such as cholera, dysentery and enteric. There is no definite proof that ants

act as carriers, but considering their habits in tropical countries, it is far from unlikely.

2. *Bed-Bugs* :—These loathsome insects are charged with the conveyance of anthrax, kala-ázár, leprosy, some skin diseases, tuberculosis, typhus fever and yaws.

3. *Fleas* :—It has been definitely proved that plague is conveyed by fleas.

4. *Non-biting Flies* :—The list of diseases laid to the door of what Sir Rupert Boyce calls the Septic Fly is a long one; it includes :—(1) anthrax, (2) eye diseases, (3) cholera, (4) diarrhœa, (5) dysentery, (6) enteric fever, (7) maggots in wounds, (8) leprosy, (9) skin diseases, (10) consumption, and (11) yaws.

5. *Biting Flies, apart from mosquitoes* :—Midges and sandflies are said to convey anthrax and blood-poisoning, whilst the tse-tse fly conveys Sleeping Sickness.

6. *Midges* :—Sambon has recently shown that Pellagra is conveyed by midges.

7. *Mosquitoes* :—These insects are the sole agents for the spread of Malaria and Yellow Fever. "No mosquitoes, no malaria" is a universally accepted sanitary dogma of to-day.

8. *Sandflies* :—These insects have been shown to convey the three-and five-day fevers which are common all over India.

9. *The Itch Insect* :—This is a member of the spider family which, in addition to causing the disease known as "itch," is charged with conveying leprosy and skin diseases.

10. *The Face Mite* :—The distressing complaint known as *acne* is attributed to this small animal parasite.

11. *Ticks* :—These pests are the agents for the conveyance of a large number of diseases of animals, and it has recently been shown that in Africa, they convey the germ of a fever which closely resembles the Relapsing Fever of India—a disease now known to be conveyed by the ordinary "pediculi" or "body lice."

Mosquito or Gnat.

Mosquito belongs to the order *Diptera* and family *Culicidæ.* Like all the members of this group it lays eggs from which is hatched a worm-like larva, which afterwards becomes converted into a *nymph* or *pupa,* from which the adult mosquito emerges. The egg, the larval and the pupal stages are spent in water, and therefore water is essential for the existance of all mosquitoes. The adult mosquito has a rounded head with prominent eyes, two antennæ, two palpi, and a prominent suctorial and piercing organ—the proboscis, an oval chest about the size of the head to which are attached a pair of membranous wings and three pairs of jointed legs. The abdomen is segmented.

The species of mosquitoes that are important to a medical man are the anopheles, culex and stegomyia. The anopheline transmits the malarial parasite from man to man. The culicinæ are responsible for the propagation of filaria, and one variety of stegomyia disseminates the micro-organisms of yellow fever.

The eggs are laid on the surface of the water and are held together by a sort of gummy material which surrounds them. They are about the size of caraway seeds and of a brownish-black colour. In the case of culex, hundreds of eggs are cemented together to form rafts, while in the anopheles each one remains separate and has an air cell which helps them to float.

In about three days the larvæ emerge from the under side of the eggs and are big enough to be seen by the naked eye. The larva swims actively about the water, and has a flattened head with a pair of big eyes, rectangular thorax studded with bristles, and a segmented abdomen with several lateral bristles. There are also two curious structures at the poserior half of the abdomen—one is a sort of fin, while the other is an air-aperture protected by valves which open and close as required.

The position of the larva in water during breathing depends on the arrangement of air apertures. In anopheles the apertures are close to the surface of the body and so the larvæ lie horizontally beneath the surface of the water. The culicinæ larvæ are supported by the syphon fringe, while their head and body hang down. Small fishes have a natural tendency to live on larvæ and they protect themselves by taking shelter in the aquatic weeds. The larvæ are very voracious and live on small aquatic plants and animals not excluding their own kind.

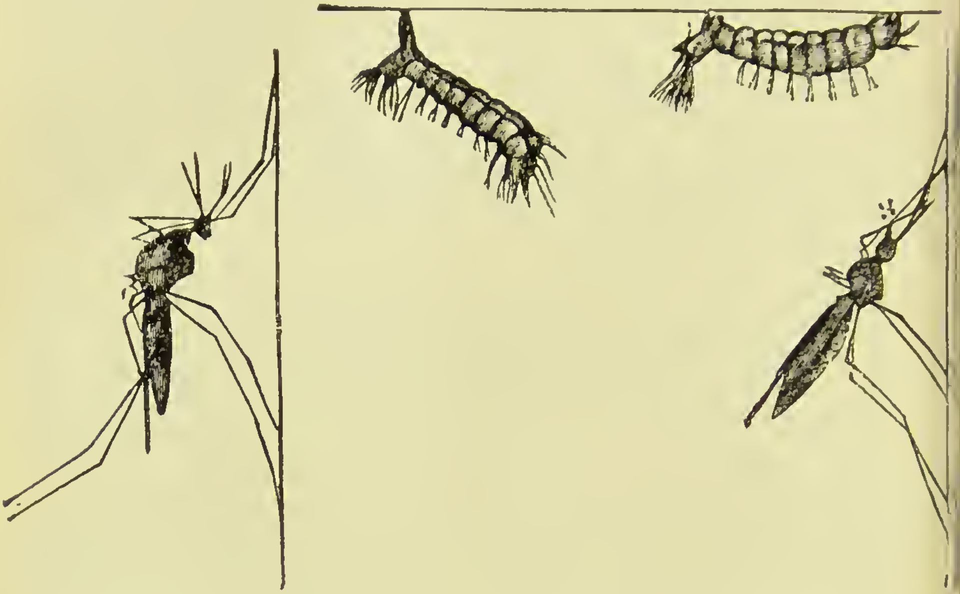

Fig. 26.

Culex larva in breathing position at surface water; resting position of adult culex.

Anopheline larva, showing breathing position at surface water; resting position of adult anopheline mosquito.

In about a fortnight the larva dovelops fully, and a new creature known as *pupa* is formed out of it. It is shaped like a comma and is lighter than water on which it floats and moves about actively. It has no mouth and therefore cannot eat; it breathes through two small tubes on each side of the thorax. In about one to two days the pupa case splits and the perfect insect or *imago* is hatched out. When the adult mosquito is ready to emerge, the pupa becomes straight and lies flat on the surface, the empty case acting as a raft on which the mosquito rests till its wings have dried.

Habits of Mosquitoes.—The adult insects particularly the males live on vegetable juices, but the females of most species are blood suckers and so their proboscis is modified for the purpose. The male mosquito therefore takes no part in the spread of the disease. The whiskers or plumes on either side of the head of the males distinguish them from the females. The majority of Indian mosquitoes are nocturnal in their habits. They obscure themselves during the day amongst shrubs and bushes, in corners, huts, &c. It is very often observed that infection generally occurs on spending the night in a malarial locality or district. Persons paying a flying visit during the day often escape infection.

The larva ceases to grow in winter, and the adult female hibernates in the dark to become active again in the hot season. Each female mosquito lays eggs several times in a season, and at each time some hundreds, and the fresh ones produce eggs within a week or so after emergence from the pupa case. It takes about a minute or so for the mosquito to fill herself, and with every bite she injects a poison which sets up

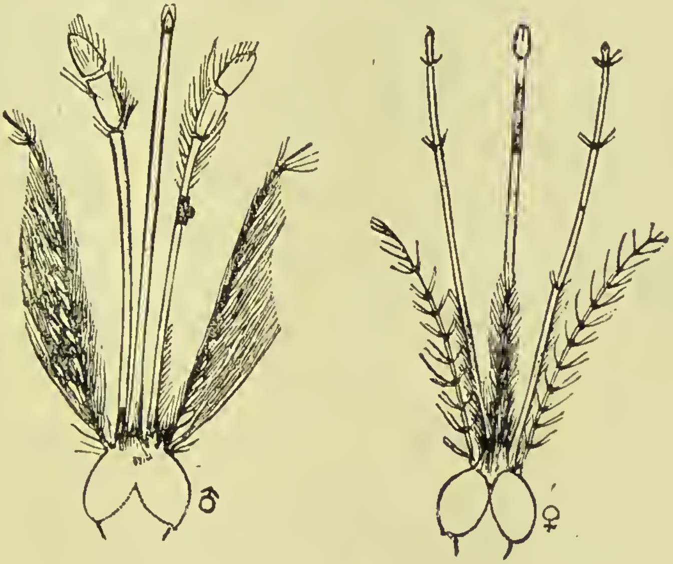

Fig. 27.
Heads of Anopheline.
Male. Female.

local irritation and inflammation and helps to keep the blood fluid, thus rendering it more easy of digestion. The plasma of the blood is excreted out leaving the more solid portion in the stomach for digestion, which is effected in one to four days when she is ready for a fresh meal. Some insects of this order closely resemble anopheles in appearance as well as in habits, chief of them are culex, sandflies and midges.

The distinguishing characters of anopheles and culex are given in the following table :*

	Anopheles.	Culex.
Egg or ovum ...	Laid separately usually. Found in tanks, wells, irrigation channels, paddy fields, rain water puddles, pools in river beds, &c.	Laid in boat-shaped masses. Found in same places as anopheles, but also in pots, tins and collections of dirty water in and near houses.
Larva ...	Has no respiratory tube. Floats horizontally.	Has a conspicuous respiratory tube. Appears to hang at various angles from surface of water.
Pupa ...	Not easily	distinguished.
Imago ...	Is generally straight.	Is hump-backed.
M. and F. ...	Rest at varying angles with a vertical wall. Wings spotted, barred or deeply coloured.	Rest parallel with a vertical wall. Wings clear, unspotted except in one or two rare species.
Male ...	Palpi bulbous at ends, same length as proboscis.	Palpi feathered at ends and pointed, longer than proboscis.
Female ...	Palpi same length as proboscis.	Palpi very short.

Breeding places of Mosquitoes.—It may be said in general that wherever there is a collection of water anopheles breed, although they naturally breed in terrestrial waters, they may breed vicariously in any collection of water, in cesspits, iron or masonry tanks and even in earthenware *chatties*. It should be noted however that anophelines are not extensive travellers, and remain in the vicinity in which they were born. Therefore their number decreases as the distance from their breeding places increases, and it may be concluded that their number in a locality is in inverse ratio to the square of the distance from breeding places. "To suppose that mosquito population will remain the same after local suppression of the breeding is equivalent to supposing that the human population of Great Britian would not be affected by abolishing the birth rate" (Ronald Ross).

---

* McNally and Cornwall : Sanitary Handbook for India.

Of the large number of described species of Anophelinæ the following are the principal hosts of the malaria parasites in India : *Myzomyia rossii*, *M. culicifacies*, *M. turkhudi*, *M. christophersi*, *Pyretophorus jeyporensis*, *Myzorhynchus sinensis*, *M. barbirostris*, *Nyssorhynchus fuligenosus*, *N. maculipalpis*, *N. stephensi*, and *N. theobaldi* (Manson).

In their Monograph on the Anophelines of India, Liston and James mentioned the presence also of the following Anophelines in Calcutta : *Myzorhynchus jamesi* and *M. barbirostris*. Dr. U. N. Brahmachari of Calcutta also discovered several additional species of Anophelines in Calcutta which have also been proved to be carriers of malaria. They are *Myzomyia ludlowii*, *M. culicifacies*, and *M. brahmacharii*.

Sandfly.

These flies act as carriers of a special form of disease characterised by fever of short duration, usually lasting from three to five days. The fever was described by Colonel Birt as phlebotomus fever from Malta and Crete. It also occurs in India in endemic form in Chitral as described by Major Wall. There are two distinct species of insects popularly known as sandflies, one belonging to the family *Simulidæ*, commonly known as Black-flies or Buffalo-gnats, the other true Sandflies or Owl-midges belonging to the genus *Phlebotomus*.

The sandflies are small dark coloured flies with humped thorax and broad wings. The larvæ live in quickly running water instead of stagnant pools and hold on to stone, weed, &c., by means of a sucker at the end of the body. Moreover they spin threads, which by anchoring them to suitable projections help to protect them from being carried away. When full grown a cocoon is formed into which it pupates. While young they are transparent but become darker as they grow. The adult flies are very active and gregarious.

Like mosquitoes the males are harmless, but the females are blood-suckers, and being of a smaller size they have the advantage over mosquitoes in getting through ordinary mosquito netting. Eyes, ears, nose and the ankles are the special points to which the pest mainly directs its attention. The bite causes much irritation and leaves a purple spot like a blood blister. They are generally to be found in or near bath rooms, near the floor, under bricks and stones and in damp shady places. They breed in places where vegetable organic matter like food refuse are undergoing decomposition, particularly in the drain and back of cook houses.

MIDGES.

Sambon has pointed out that midges convey *pellagra*. These little blood thirsty insects are very annoying to man. They are easily distinguished from the mosquitoes by their small head, short proboscis, and by the absence of scales on the body and wings and different venations. In their resting attitude they raise the forelegs and hold them up in front of the head, while the mosquitoes raise the hind ones above the thorax and abdomen. With the exception of one variety, which is terrestrial, all the other species lay eggs in water and pass through the same stages as those of the mosquito. The larvæ of the terrestrial variety feed on rotten vegetable matter.

FLIES.

Flies belong to the family *Muscidæ* and the common house-fly and blue-bottle are familiar to all. Almost all other different species closely resemble either one or the other of these two types. They all lay eggs numbering about 20 to 30 at a time, while others like the blue-bottles as many as five or six hundred. The eggs are, as a rule, white and hatched within 24 hours. The larvæ are scavengers and live in dung or decaying animal or vegetable matter. These are the typical "maggots".

The house-fly of India breeds in decaying refuse of all sorts and specially partial to horse manure. It is also observed that the fly has developed a taste to breed on human excreta, which habit, however, makes it very dangerous to human beings, carrying, as it does, the germs of intestinal diseases. Excepting the important group of blood-sucking muscidæ, flies, as a rule, cannot bite, and therefore are not blood-suckers. They therefore act as carriers of disease in a purely mechanical way. They convey on their feet and other parts of their body traces of the filthy matter on which they usually sit and suck and thus contaminate the food and milk with the germs of intestinal diseases. C. Gordon Hewitt states that Prowezek has found a flagellated protozoon allied to the trypanosome in the house-flies which he examined. The discovery of this parasite in the common house-fly is of great importance since it is believed that Kala-azar is due to a species of Herpetomonas.*

The capacity of the house-fly to carry disease germs has been experimentally proved by Nuttall, Firth, Horrocks and other observers.

Of the blood-sucking flies, the most important is tsetse fly which belongs to the genus *Glossina* and acts as the carrier of the parasite trypanosome giving rise to sleeping-sickness. It was formerly supposed that the parasites were conveyed in a purely mechanical way carried in the insects' proboscis, but recent observations by Kleine and Bruce tend to prove that glossina serves as an alternate host in a purely biological sense, and that the trypanosome after entering the intestinal canal of the insect undergoes developmental changes which enable it subsequently when opportunity offers to effect a lodgment in some vertebral host.

---

* J. T. C. Nash : Bombay Medical Congress, 1909.

Tse-Tse Fly.—The study of tse-tse flies and the diseases disseminated by them is not only of scientific interest but of great practical importance. This is evident from the fact that some thousands of the natives of Uganda have died from sleeping-sickness alone—a disease disseminated through tse-tse fly. Austen characterises the tse-tse fly as follows:

"Tse-tse may be described as an ordinary looking sombre brownish or greyish or brown flies, varying in length from 3½ to 4 lines in the case of *Glossina morsitans* to about 5½ lines in that of *Glossina fusca* or *longipennis* with a prominent proboscis in all species. The hinder half of the body or abdomen in the best known species, though not in all, is of a paler colour and marked with sharply-defined dark-brown bands which are interrupted on the middle line; the abdomen, however, is invisible when the insect is at rest as it is then concealed by the wings. The sexes of tse-tse flies can readily be distinguished since in the male the external genitalia form a conspicuous knob-like protuberance (hypopygium) beneath the end of the abdomen which is absent in the females." When in a retiring attitude the wings overlap on the back crossing each other. This not only gives the fly an elongated appearance but serves to distinguish it from other blood-sucking diptera.

Tse-tse flies are confined to Africa: they are found along the banks of rivers, springs, coasts of lakes, open pools, and sandy banks especially at the foot of mountains. The places occupied by the flies are known as "fly belts."

Tse-tse flies are voracious blood-suckers exhibiting great persistency in their attacks on man and animals. They bite almost exclusively during the day. Contrary to what is the case among horse-flies *(Tabanidæ)* and mosquitoes (*Culicidæ*), of which the females alone suck blood, in the tse-tse both sexes are blood-sucking (Manson).

Besides these certain larvæ of the dipterous insect, like screwworm, or of sarcophagidæ, cause myiasis in man. The larvæ are deposited in open wounds and in the ear and nasal fossæ, especially of those having offensive discharges which attract the fly. They fix and borrow in the tissues giving rise to pain and blood poisoning which might end fatally.

Protection against Flies.—Since flies breed in filth and dung, or decayed animal or vegetable matter, measures should be taken to remove refuse, especially stable refuse, daily, or to protect them with a layer of lime, by copiously sprinkling with crude oil solution or a solution of cyllin, or by keeping them soaked in water, or in fly-proof bins or pits. Kitchen should be kept scrupulously clean and refuse of any kind should not be thrown about in or near it. Food should be kept in close shutting wire netting almirahs or safes or so covered as to protect it from flies.

The following measures may be adopted to prevent fly-nuisance:*

1. Destroy all decaying vegetable and animal matter by burning it if possible. If this cannot be done, sprinkle it freely with chloride of lime, kerosine or other cheap disinfectant. Flies breed in filth. Keep all garbage carefully covered and scald cans frequently. Never allow filth of any kind to accumulate about the premises—specially near the house.

2. Screen doors and windows—specially those of a sick room and those of the dining room and the kitchen. See that all food is screened ; be specially careful to do this when there is a case of contagious disease in the house or neighbourhood. Remember the housefly carries disease germs chiefly by picking them up—somewhere, but not on flowers—and carrying them to food of various kinds—not a pleasant thought, but instructive.

3. Each day institute a still hunt for the flies which will find their way into the house, with even the best of screening, and kill them. After you have done your best there will still be flies and to spare, but it is worth while to lessen an evil if you cannot eradicate it. And the house-fly is an unmitigated evil.

---

* *The Dietetic and Hygienic Gazette :* June, 1912.

FLEAS.

Fleas belong to the order of *Diptera*, but they differ from other insects of this order in not possessing any wings and in having the form and structure profoundly modified in consequence of their parasitic habits. They have a body flattened laterally and have a head, thorax and abdomen. The head is united behind to the thorax. "The beak is composed of an exterior jointed sheath, having inside it a tube, and carrying underneath two long sharp lancets, with cutting and sawlike edges. It is with this instrument that the flea pierces the skin and sucks the blood."

The males are smaller than the females, and the females have less abruptly tip-tilted tail. The eggs are oval, smooth and white, and about eight to twelve are laid on floors, dirty carpets or dry earth. They also pass through larval and pupal stages. It takes about five days in summer and eleven days in winter for the larvæ to come out of the eggs. When full grown they spin a cocoon usually covered with dust and dirt in which they are transformed into pupæ. In another fortnight they become perfect insects.

Rat Flea.—*Pulex cheopis* is the common rat flea of India and of the tropics, and acts as passive intermediatary and carriers of *B. pestis*, not only from rat to rat, but from rat or other infected animals to man. It has been discovered by Zirolia that *B. pestis* multiplies in the stomach of the flea, retaining its virulence for over a week and then passed out in the fæces. Flea therefore acts not only as a carrier but also as a multiplier of the germs. It has also been shown by the experiments of the Indian Plague Commission that if fleas are

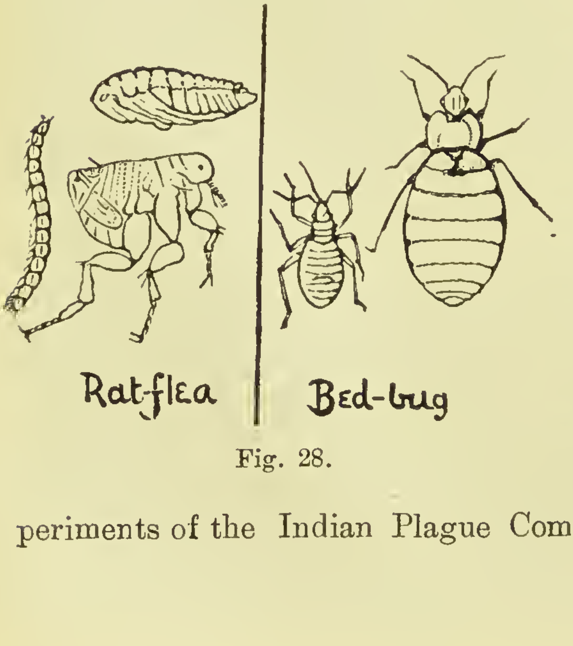

Fig. 28.

excluded, healthy rats will not contract the disease even if kept in touch with plague infected rats. It resembles very much the common flea, *Pulex irritans*, but it is smaller and light coloured and has a number of bristles on the head.

Sand Flea or Chigger.—This is an excessively troublesome insect found in the West Indies and West Coast of Africa. It has now extended to the East Coast of Africa whence it has been carried home by Indian coolies. It lives on the ground and is abundant in dry sandy soil, particularly near sea shore ; dirty rooms and huts, stables of cattle, &c., are the favourite haunts of these insects.

The chigger resembles the common flea but is a little smaller, head being comparatively larger. It is reddish brown in colour and attacks all warm blooded animals including bird and man. Being nearest the ground, feet are the most common parts attacked by chiggers. The scrotum, penis, the parts round the anus, thighs, head and face may also be attacked.

The female when impregnated makes her way under the skin and becomes almost a motionless bladder through the enormous development of the ovary. During this period it sets up much irritation with inflammation and formation of pus which gives an appearance of pea-like elevation. When the chigger is expelled out a small sore is left behind. These insects are held responsible for causing suffering, invaliding and indirectly death.

BED BUGS.

At least one way in which kala-azar is transmitted from man to man is by the bite of ordinary bed bug. The ubiquitous tormentor is found to have a greater importance as a carrier of disease than as a simple household nuisance. In India two species, *Cimex lectularius* and *C. rotundatus*, attack man. The flattened reddish brown colour which characterises them is familiar to all. It appears that bed bug was originally a parasite of birds and mammals,but although it is confined chiefly to man it has other hosts as well. It has a very wide distribution and can survive long periods—even a year—without food (Lefroy). The eggs are lain in any place where the female ones can gain access—in cracks and fissures, in furniture, &c. Like a mosquito it injects an irritating fluid which causes a flow of blood to the spot on which it engorges itself.

Bugs are nocturnal in their habits, but seem to be active at all times. They are usually found in any numbers in dirty beddings, clothes, in cracks in the floor and walls, in chairs, railway carriages, tramcars, &c.

Fumigation with hydrocyanic acid and formaldehyde is often resorted to in railway carriages and buildings. Superheated steam may with advantage be tried in India. Absolute cleanliess is essential, and scrubbing the floors and bed-steads with kerosine oil, turpentine or pyrethrum powders helps to destroy the pests.

TICKS.

Ticks as a class of ectoparasites are most abundant in warm countries. This is ascribed to the fact that cold is unfavourable to the requirements of the egg and all the stages in early life. They form a very important class of blood-suckers and play an important part in the transmission of disease, closely simulating the relapsing or famine fever of India. They attack all types of terrestrial vertebrates, most mammalia, the aves, some reptilia and amphæbia. The ticks are sufficiently big to be seen by the naked eye and the females are usually larger than the males. As a rule the ticks are temporary parasites ; some may live in a quasi-permanent manner, others again—as the sheep tick—may burrow beneath the skin.

The female lays eggs in large numbers on the ground and then dwindles up and dies. The eggs are small grains of a yellowish colour and in two or three weeks' time they are hatched giving rise to larvæ, which look like minute moving grains of sand and are characterised by having six legs, no stigma and no sexual organ. After a short period of rest the larvæ seek food ; they swarm up to the tips of the blades of grass and await in clusters their warm-blooded host. It then becomes gorged with blood of the host and passes through its first moult and emerges through the larvæ skin as a nymph.

The nymph presents four pair of legs but still no sexual organs. Like the larva it moves about until it attaches itself to some warm-blooded host and then drops off to moult again when it becomes sexually mature. Having thus reached maturity the sexes unite. After fertilization the male dies while the female proceeds to feed on the blood of her host for the development of her ova. On account of the difficulty of finding a suitable host ticks at all stages are endowed with a phenomenal capacity for fasting. In fact they have been found alive after a fasting of four years' duration (Manson).

The ticks are nocturnal in their habits like bed bugs and live in the huts of the natives, cracks and crevices in the walls, floors, &c. They are frequently carried in mats or bedding, or importers' loads which have been stored in rest huts at nights.

The species of ticks which are of special interest are *Ornithodoros moubata* and *Argas persicus* ; the former is the transmitter of the spirochæta of African relapsing fever, the latter of the germs (spirochæta ?) of the Miana Disease.

A certain form of fever prevalent in southern parts of the Madras presidency and ulcers are, it is believed, due to a variety of tick found in abundance there.

CHAPTER XVIII.

RESTRAINT OF INFECTION.

Remembering the different ways in which infection may be carried, it is necessary that the atmosphere should as far as possible be pure, the water and milk above suspicion, and streets and houses kept rigidly clean. But, should infection break out certain measures have to be adopted for restraining or preventing the spread of the disease. They are—

1. *Notification*—which requires every practitioner who diagnoses a case of infectious disease to notify to the Health Officer or Civil Surgeon of the district to enable him to take necessary precautions at once.

2. *Isolation* of the infected person.

3. In certain more dangerous diseases like plague, small-pox, &c., *quarantine* may be imposed on persons who have been in contact with the patient.

4. Protective inoculation or production of *artificial immunity.*

5. *Disinfection.*

1. NOTIFICATION.

By "notification" is meant the immediate intimation of the outbreak of every case of infectious disease to the Health Officer or Sanitary Authorities.

Notification of all infectious diseases to the sanitary authorities is only a means to an end, as it enables the medical officer of health to take immediate measures for preventing further spread of the disease by isolation and disinfection, and other necessary action. According to Dr. Whitelegge the advantages of compulsory notification are :

(i) Early and complete knowledge of all cases of notifiable disease, and thus of the whole prevalence and distribution in the district or town.

(ii) Power to exercise such supervision as may be necessary over every case during its whole course, and to enforce due observance of the provisions of the Public Health Act as regards isolation and disinfection. This is of great importance in cases of outbreaks of diphtheria, scarlet fever or typhoid fever in dairies, schools, &c.

(iii) Opportunity of removal to hospital of every suitable case; other preventive measures as vaccination in cases of small-pox can be offered.

(iv) Opportunity of investigating the sanitary condition of all households in which cases of enteric fever or diphtheria or other notifiable disease may occur.

(v) Power to control the spread of infection through schools or other centres by excluding members of infected households.

(vi) Means of detecting at once any suspecious grouping of cases around schools, milk supplies, water supplies and other common focus.

Immediate notification enables the authorities not only to isolate the sufferers and thus prevent them from acting as centres for disseminating the disease, but also to find out the real and original source of the disease. With the poor isolation into a hospital not only ensures them proper treatment but also better comfort.

There is no notifiable disease act in India. Only a limited number of municipalities and the presidency towns enjoin medical practitioners to report infectious diseases, particularly cholera, small-pox, plague, typhoid fever and diphtheria, occuring in private or public houses. But this proved to be of little value. It is important also that the sanitary authority should be in a position to adopt immediate steps for the seclusion of patients at home and for their removal with due care to special isolation hospital.

2. ISOLATION.

Isolation is seperation of the sick, in case of any infectious disease, from the rest of the household to render transmission of contagion from the sick to the healthy impossible. For persons in easy circumstances isolation can be satisfactorily carried out at home. But for the poor who live in insanitary *bustees* or quarters, with insufficient accomodation, and in schools, workshops, &c., the sick should always be removed to the nearest isolation hospital as soon as the infective nature of the disease is recognised.

Home or Private Isolation.—For the isolation of persons suffering from infectious diseases in their own houses the following points should be observed :—

(i) Whenever practicable the number of rooms should be two, on the top floor or on a detached portion of the building.

(ii) All furniture, clothes, &c., not required for the patient, should be removed before hand.

(iii) The doors should either be kept closed, or a screen soaked in some disinfectant solution, like 1 in 20 carbolic acid, should be hung over. This not only prevents germs from being carried by wind, but also acts as a danger signal to the visitors.

(iv) The windows should be kept open for free circulation of air.

(v) A fire may preferably be kept for destroying waste materials like rags contaminated with discharges.

(vi) No one excepting those who are in actual charge of the patient should be allowed in the room. The nurses or attendants should take good care to wash their hands with some antiseptic lotion and disinfect their changed clothes. The dress of the attendants should be of some non-absorbent materials which can readily be washed. Fresh dresses for nurses and attendants should be kept in the adjoining room.

(vii) No clothing or utensil should be taken out of the sick room without previous disinfection.

(viii) Excreta and food remains should be removed in vessels containing some strong antiseptic and then buried or burnt.

(ix) Neither visitors nor any member of the house should enter the room, but if necessary should speak through the screen or window.

(x) When the danger of infection is over, the patient should be washed and bathed thoroughly with soap and water, and have a complete change of clothes before being allowed to mix with other people.

It need hardly be said that the above precautions are very difficult to be carried out thoroughly in a private house, even if the patient and the family give the most willing assistance. It is better whenever possible to remove the patient to a hospital, where he will be less dangerous to his own people and his neighbours. It should be remembered that a very imperfect and incomplete isolation is better than none, and may serve a useful purpose in checking the spread of infectious diseases.

Isolation Hospital.—In every large town it is necessary that provisions should be made for the accommodation and treatment of infectious cases. This is best carried out in an isolation hospital. The essential features of an isolation hospital are that the site should be dry, healthy and well drained, and although well away from congested quarters yet not far enough to cause inconvenience. Separate wards should be provided for admission and treatment of different infectious diseases. In India this is only done for cases of smallpox, cholera and plague. A floor space of 144 square feet should be allotted for each patient. There should be a special observation ward where all suspected cases should be kept.

Proper arrangements should be made for removal of excreta and disinfection of soiled clothes, bedding, &c. It is better to keep separate ambulances for the removal of the sick, but whenever ordinary carriages or *palanquins* are used, care must be taken to thoroughly disinfect them.

Ambulances.—Ambulances may be either wheeled or carried on shoulders as *doolis*. When wheeled, they should better be rubber tyred, and may be drawn by horse, bullock or man; but the wheeled ones drawn by men appear to be the best of all. Ambulances should be kept in all police stations and public places, and should be thoroughly disinfected after each use.

Segregation of the inmates of the infected houses in special camps is sometimes adopted as a precautionary measure for early detection of any case occurring amongst them. During the first outbreak of plague this method was adopted by the Government of India.

Investigation of Infectious Disease.—According to Dr. Whitelegge enquiries on the following points should always be made in investigating a case of notifiable disease :—

(1) *Patient.*—Address, name, sex, age, date of onset, date of rash, present and past isolation, probable source of infection, recent contact with infected persons or things.

(2) *Household (including patient).*—Sex and age of each inmate, susceptibility (as shown by history as to previous attack), date of previous attack (if any), occupation, place of work or school, and date of last attendance thereat.

(3) *Work or business carried on in the house.*

(4) *Water supply and milk supply.*

(5) *Sanitary condition* of the premises and surroundings.

(6) *Previous cases* of the disease in the home or in the vicinity, or at the school or work place.

In dealing with an outbreak of small-pox further enquiry must be made regarding the condition of each individual as to vaccination and revaccination, noting the dates. These should be supplemented by enquiries about the appearance in the house of rats (dead or living) in cases of plague, and about certain other domestic animals, *e.g.* cows in cases of scarlet fever, and cats, fowls or pigeons in cases of diphtheria.

3. QUARANTINE.

In the modern acceptance of the term "quarantine" means arrest of communication with infected places except under certain restrictions. This is specially restricted to the detention of healthy travellers after their departure from an infected place. The period of detention should cover at least the longest incubation period of the disease. In theory quarantine appears to be a very effective way of stopping communicable diseases, but in actual practice this has invariably failed. The disadvantages are that it imposes restrictions on commerce and causes inconvenience to travellers.

Quarantine may be (i) *inward, i.e.,* when qurantine is imposed on a healthy town for its own protection, or (ii) *outward,* when it is imposed on an infected town or village for the protection of the surrounding country. If the patient is removed to a hospital, and disinfection of the infected house is properly carried out, it is not necessary to keep the family under quarantine. If the case is treated privately, the household must be placed under quarantine until the last case has ceased to be infectious and the final disinfection has been completed. From a hygienic point of view the movements of all persons exposed to the infection should be limited. Hence quarantine has been conveniently divided into :

(*a*) *International Quarantine.*—This consists in compulsory isolation at the port of all persons coming from an infected place, or persons who had been in contact with any case of infectious disease against which quarantine has been imposed.

(*b*) *Scholastic Quarantine.*—Since children are more susceptible to infection, it is necessary that due measures to check the spread of the disease should be taken. Children from an infected house during the period of quarantine should not be permitted to attend the school until the last case has ceased to be infectious. Closing of schools should be enforced unless there be a clear prospect of preventing the spread of the disease. If the attendance is greatly reduced by absence or exclusion of a large number of students it is advisable to close the schools.

(*c*) *Domestic Quarantine.*—This becomes often necessary for members of an infected household. In case of smallpox every member of such a house should be placed under a strict watch for a period of at least ten days after the last contact or until such persons are successfully vaccinated. Quarantine should also be insisted upon milkmen (*gowalas*), tailors, &c. All persons, particularly children, should be strictly prohibited from entering into an infected house. It is also necessary to prevent the importation of rags, jute, &c., from infected places or ports.

Objections to Quarantine.—According to McNally and Cornwall the objections are as follows :

(1) The infective period in some diseases being much longer, the infected persons and the contacts may carry infection for a longer period than can well be covered by quarantine.

(2) Quarantine very often interferes with food supplies, and may thus cause privation and predisposition to disease ; and by interfering with trade it alters prices and affords strong temptation for its own evasion.

(3) The association of the healthy with the sick in a place (lazaretto) is not only undesirable, but tends to keep the disease alive.

(4) The disease is very often concealed owing to fear of quarantine.

A modified system of quarantine is therefore of special value in India, and consists in "making all arrivals from an infected district take out passports which bind them to present themselves for inspection daily for a period of ten days. Persons who appear to be suffering from plague are at the same time detained and isolated, and beggars and loafers, who can give no address and who cannot be relied on to report themselves, are also liable to detention. If a passport holder fails to report himself he can at once be hunted up and safely dealt with."

4. IMMUNITY.

By *immunity* is meant non-susceptibility to a given disease or a given organism either under natural condition or under conditions experimentally produced. Jenner in the later part of the eighteenth century first achieved the triumph in the prevention of small-pox by means of vaccination, and further progress was made in this direction by the researches of Pasteur in hydrophobia and anthrax ; Koch in tubercle ; Loeffler, Behring, Roux and Kitasato in diphtheria, tetanus. and pneumonia ; Haffkine in plague and cholera ; Ross in malaria ; and Wright in enteric.

For purposes of description immunity may be classified as follows:

- A. Natural
- B. Specific
  - 1. Acquired (from disease)
    - a. Permanent,
    - b. of moderate duration,
    - c. of short duration.
  - 2. Artificial
    - a. Active or isopathic.
    - b. Passive or antitoxic.

A. **Natural or Innate Immunity.**—This form of immunity is possessed by a man or animal either from birth or acquired during growth by virtue of its species, race or individual peculiarities. As instances may be mentioned the immunity of hens against tetanus, and goats, sheep and rats against tubercle. Certain races of mankind are immune to certain diseases—the negro is said to be immune to yellow fever. Again, some families are more susceptible to certain diseases than others. Absolute immunity is however impossible, and even a hen may develop tetanus if the dose be considerably large. It seems probable that all men possess a certain amount of resistance against all micro-organisms, but this power of resistance varies with different individuals. It is a known fact that in times of epidemics all who have been exposed to infection do not take the disease, and even in those who take it some will have a severe or even fatal attacks than others.

B. **Specific Immunity.**—This may result either by passing through a specific disease, or as a result of artificial inoculation.

1. **Acquired Immunity.**—It has long bean recognised that an attack of infectious disease confers a certain amount of immunity on the person from a second attack. The degree of immunity, however, varies and may be

(*a*) *Permanent*, *i.e.*, very strong and may last for a considerable period, and often for the whole life of the individual, as in syphilis, small-pox, &c.

(*b*) of *moderate* duration as in measles, diphtheria, &c.

(*c*) of a very *short* duration as in cholera, influenza, &c.

2. **Artificial Immunity.**—There are two methods of artificial specific immunisation : they are known as *active* or *isopathic* and *passive* or *anti-toxic.*

(*a*) *Active or Isopathic Immunity.*—This is obtained by inoculation (i) of living virulent virus, (ii) with living yet attenuated virus, (iii) with dead virus, (iv) with bacterial cellular substances of the same, and (v) with dissolved toxic products of bacteria.

By repeating these injections in gradually increasing doses at suitable intervals a very high degree of immunity is ultimately produced against the particular organism that has been used for the injections. It is obvious, however, that such a method of inoculation can only be *preventive* as it takes a long time to develop. It can never be curative as the immunity must be developed before the onset of the disease. Once produced, however, it affords protection for a long time.

The term *vaccination* is used to all methods of protective inoculation, and the attenuated cultures or toxins which are used for this purpose are spoken of as *vaccines.*

(*b*) *Passive Immunity.*—"This depends upon the fact that if an animal be immunised to a very high degree by the previous method, its serum, when injected into a susceptible animal, will confer immunity upon it provided that it is introduced at the same time as infection occurs or even a short time afterwards. This method, therefore, can be applied as a *curative* agent, but the passive immunity thus conveyed only lasts for a short period, because in this case there is no active production of "anti-bodies" in the blood.

When the serum of an animal is used in this way for the production of passive immunity in another animal it is found that its effects differ according to the original method of inoculation. If the micro-organisms themselves are used (whether living or dead) the serum is markedly *bacteriolytic,* but it has little power of neutralising toxins : it is therefore said to be *anti-microbic.* On the other hand when filtered toxins are used for the original inoculation the serum of the immunised animal has the power of neutralising the toxin and it is said to be *anti-toxic.*"*

5. DISINFECTION.

Disinfection means destruction of specific virus of infectious disease. *Disinfectants* or *germicides* are substances which destroy pathogenic microbes, *i. e.* those which cause communicable diseases and so prevent them from spreading. Disinfectants must not be confounded with *antiseptics* or substances which stop bacterial growth and thus prevent or retard putrefactive changes, *i.e.* decomposition of vegetable or animal matter. *Deodorants* or *deodorisers* oxidise products of decomposition and so absorb or destroy offensive smell.

Practical disinfection is utilised for—

(1) Destruction of microbes deposited on walls, crevices, floors, surfaces, &c., of rooms, furniture and other domestic articles ;

(2) the destruction of infectivity of excreta and other discharges ;

(3) preventing the spread of infection by men ; and

(4) destroying *in situ* such microbes as though pathogenic, have also an extra-corporeal or saprophytic existance.

It is not enough to know that a substance is a disinfectant, but the quantity to use and the degree of concentration required are important factors ; it is also necessary that the disinfectant must come in direct contact with the micro-organisms. Some deodorants again destroy offensive odours by simply substituting an agreeable or some other strong smell without destroying the organisms giving rise to putrefactive odours. These are worse than useless.

---

* Ghosh : Materia Medica and Therapeutics, 4th Edition.

For practical purposes disinfectants may be classified as follows :

I. Natural.
II. Physical.
III. Chemical.

I. Natural Disinfectants.

Fresh air and sunlight are the natural disinfectants and kill most germs. By process of desiccation all micro-organisms are sooner or later attenuated in their disease-producing activities. Typhoid, tubercle and diphtheria bacilli resist drying for a long time, gradually losing their vitality. In fact it has been proved that direct sunlight will kill typhoid bacilli within one-half to two hours and diffused daylight in about five hours. According to Koch tubercle bacilli are killed by the sunlight in from a few minutes to several hours according to thickness of the mass exposed. Drying on the other hand resists multiplication of bacilli, and putting in the sun and air of bedding, clothes and other articles often secures the desired degree of dryness, while the oxygen of the air exercises a toxic influence on the organisms that may have harboured in those articles.

Sunlight aids disinfection to a great extent. Direct solar rays are more powerful than diffused daylight. Although a large number of micro-organisms, *e.g.* of diphtheria, plague, &c., are destroyed by the rays of the sun, yet as disinfectants sunlight cannot absolutely be relied upon. The ultra-violet rays of the sun have a powerful restraining action on the growth of bacteria.

II. Physical Disinfectants.

Physical disinfectants include heat in its various forms and may be applied as :

A. Dry heat,—
    1. burning by fire,
    2. hot dry air.

B. Moist heat,—
  1. boiling,
  2. steam.

A. Dry Heat:

(1) *Burning.*—This is the best way of disinfection and should always be employed for articles of small value, *e.g.* rags in which discharges have been received, pillows, old mattresses, &c. The destruction of all these articles is usually carried out in a small destructor-furnace which should also form a part of the disinfecting station. If carried out in open air small unburnt particles carrying infection may be scattered by wind. Cholera and enteric excreta should be burnt down by mixing them with sawdust and kerosine oil to ensure their thorough and complete destruction.

Cheap dwellings like huts that can readily be reconstructed should better be disinfected by fire, especially where diseases like plague had occurred.

(2) *Hot Dry Air.*—Formerly this was the principal method for disinfecting clothing, bedding, &c. But this is being replaced by steam disinfection which has many advantages. The only advantage claimed for this method is that leather goods, india rubber, fur, bound books, &c., are not damaged by it.

B. Moist Heat:

(1) *Boiling.*—This is one of the most efficient methods of disinfection. Infected articles can be disinfected within about 20 minutes by boiling. It takes about 10 minutes to kill typhoid bacilli at a temperature of 140° F. and 5 minutes for comma bacilli at 126° F. Spores of many pathogenic micro-organisms are killed by boiling for 5 minutes. On the other hand bacillus anthracis, B. tuberculosis, and streptococci of puerperal fever require boiling for a longer time for their destruction. This method is very often resorted to for disinfecting beds, linen, &c. Clothes stained with blood and fæces should first be cleaned with soap and water, and then subjected to boiling. An addition of 2 per cent of washing soda accelerates the germicidal power of boiling

water. The disadvantages of this method are that it is slow, and not suited for woolen materials which shrink, and that it fixes albuminous stains.

(2) *Steam.*—This is the most efficient and practical way of applying moist heat for purposes of disinfection. It will destroy all micro-organisms and spores at a temperature of 212° F. in five minutes, whereas hot dry air would require a temperature of 250° F. for four hours. Steam used may be either *saturated* or *superheated*, according as it is capable of condensing without requiring increased pressure or reduced temperature. Steam may be produced at ordinary atmospheric pressure at 100° C.; but when generated at a temperature exceeding 100° C. under increased pressure it always remains a saturated steam. If on the other hand the temperature of the steam is further raised without increasing the pressure it becomes superheated. Superheated steam may also be produced at atmospheric pressure from a saline solution. This superheated steam is called *dry steam*, and will not condense unless the extra heat from it has been separated by the slow process of conduction. The saturated steam, being a vapour, condenses to $\frac{1}{1600}$th part of its original volume as soon as it comes in contact with articles slightly cooler than itself, and by giving off its latent heat becomes smaller in volume, consequently more steam is drawn into the partial vacuum thus produced, and the process is repeated until every portion of the article is acted upon by the steam. When disinfection is complete no further condensation of the steam occurs. With superheated steam disinfection occurs in the same way as with dry heat. Therefore disinfection by saturated steam should always be preferred on account of its more rapid and thorough penetration.

Steam, whether superheated or saturated, may be *confined* into a closed chamber or may be employed as a *current* steam. In both these conditions it may be used either at the ordinary or higher atmospheric pressure.

Current steam disinfectors although cheap at the outset are expensive in the long run because they consume more fuel. It should be noted that higher the pressure of the steam the more rapid the penetration, and the less time required for disinfection. A temperature of 115° to 120° C. for twenty minutes is alone trustworthy in all cases.

Steam Disinfecting Station.—A disinfecting station should consist of two rooms—one for the infected and the other for the disinfected articles. Each room should have a separate entrance and completely separated from each other by a wall—into which the stove is built, which communicates with both the rooms. The infected articles should be placed on trays which can be easily introduced or removed from the disinfector. The time required for disinfection depends on the bulk and the nature of the infected articles and the pressure of the steam employed. There should be arrangements for ascertaining the temperature of the interior of the stove at any time.

All disinfecting apparatus are divided into :

(1) *High pressure* disinfectors using confined steam which is usually derived from a separate boiler, and

(2) *Low pressure* disinfectors using current steam—the steam being derived from a boiler which usually forms a jacket round the disinfector.

The disinfecting apparatus in common use are the following:

1. The Washington Lyons.
2. The Equifex.
3. The Thresh.

It should be remembered that some fabrics are damaged by heat : woolen materials shrink when moist heat is applied and acquire a distinct yellow tinge when exposed to steam at 260° F. for about 30 minutes. Feathers become yellow or brittle after an exposure for four hours to moist heat at 260° F., silk, cotton and linen will stand a moist heat of 260° F. for half an hour and dry heat of 230° F. for four hours with little damage. Majority of substances will stand a temperature of 230° F. without much injury.

III. CHEMICAL DISINFECTANTS.

The number of chemical disinfectants is very large and may either be *solid, liquid* or *gaseous.* A chemical disinfectant must possess the following properties :

(1) It must be a powerful germicide.

(2) Its chemical properties should be such as to render it fit for ordinary use and not rendered inert by fæcal or any polluting material.

(3) It should not have any injurious effects on human tissues and materials submitted for disinfection.

(4) It should be soluble either in water, or when brought in contact with infected articles.

(5) It should be fairly cheap.

(6) It should not be a virulent poison.

. The following chemicals are ordinarily used :—

Carbolic Acid Powder.—This is chiefly used as a deodorant, but is of questionable value. Of the different varieties, Calvert's carbolic acid powder which is made by mixing the acid with the silicious residue obtained from manufacture of aluminium sulphate from shell is more satisfactory.

Lime.—Freshly burnt lime is a cheap and good deodorant by virtue of its absorbing H_2S. Lime washing is a most useful way of disinfecting houses. and it has been found that ordinary white washing destroys most of the micro-organisms.

Perchloride of Mercury (Corrosive Sublimate).—It is a powerful and cheap germicide. A solution of 1 in 1000 destroys spores in from 15 to 30 minutes. while the bacilli themselves are killed within 30 seconds. There are certain drawbacks to its use, *viz.*, (*a*) it acts upon metals, (*b*) its germicidal property is neutralised by its coming in contact with albuminous substances when it forms an insoluble albuminate of mercury, (*c*) it is not a good disinfectant for linens.

It is highly poisonous, and as it forms a colourless and odourless solution it is usually coloured with some harmless aniline dye to avoid accidental poisoning. In the form of tablets they are commonly sold as 'soloids' or 'solubes', and one tablet in a pint of water forms a lotion of the strength of 1 in 1000.

Half an ounce of perchloride of mercury, 1 ounce of hydrochloric acid, and 1 grain of aniline blue, to 3 gallons of water forms an efficient lotion and costs only four annas.

Mercuric Iodide is less poisonous, and does not precipitate albumin. Although it is not soluble in water it is dissolved in excess of potassium iodide and sold under the name of mercuric potassium iodide.

Carbolic Acid or *Phenol.*—Phenol is crude carbolic acid and is obtained from distillation of tar. Carbolic acid is the most widely used of all phenol derivatives. A 2 per cent solution will kill ordinary sporeless bacilli in from a few minutes to ten hours, while the spores are destroyed by a 5 per cent solution in about 24 hours. The disinfecting power of carbolic acid is greatly aided by the addition of mineral acid. As a disinfectant its working strength should be 1 in 20.

Phenyle is a very popular disinfectant. Although it is little more powerful than carbolic acid it has the advantage of being cheap.

Many coal tar preparations are on the market and are of much value. They are mostly of dark brown colour, form a milky emulsion with water and have the advantage over carbolic acid in being practically non-poisonous and cheaper. They are :

Izal.—It is an exceptionally powerful germicide for bacilli of the Coli-typhoid group. A solution of 1 in 500 completely disinfects typhoid stool in 15 minutes and 1 in 600 renders typhoid urine aseptic in five minutes (Klien).

Cyllin is similar to izal as regards its disinfectant properties.

Creolin.—It is an emulsified cresol in a solution of hard soap and is about ten times less weak than phenol as a disinfectant. Albumin makes it somewhat inert.

Lysol is a dark coloured liquid and a solution of cresol (50 per cent) in neutral potash soap. It is soluble in water, and a 2 per cent solution destroys ordinary bacteria in an hour. It is more effective than creolin and not readily acted upon by albuminous fluids. The working strength of the solution should be 1 in 25.

Chinosol.—This is an odourless non-irritating powder, and a solution of 1 in 1200 forms an efficient germicide.

Potassium Permanganate.—It acts as a powerful germicide but it stains fabrics brown. It is generally used as a powerful disinfectant in 5 per cent solution, but in less than ½ per cent solution it acts only as a deodorant. It is expensive and very soon becomes inert.

Soap.—Common soap is one of the most widely used disinfectants and affects most of the disease germs. The germs are actually killed by the alkali of the common soap and by washing away the grease exposes them to the action of other powerful disinfectants.

Sulphurous Acid.—It is chiefly used as a gaseous disinfectant. It is usually obtained by burning sulphur. To be of any use all the openings of the room should .be completely closed and about a pound of sulphur broken and moistened with methylated spirit should be allowed to burn in a vessel. The room should be kept closed for a few hours. One pound of sulphur when burnt gives off 1·12 per cent of SO_2 for 1000 cubic feet of space, and three pounds of sulphur are usually required for disinfecting the same area. Another way of generating SO_2 is to burn an ordinary benzoline lamp after charging it with carbon disulphide. SO_2 is evolved as carbon disulphide is consumed. Now-a-days sulphurous acid liquefied under pressure can be had from the market.

Chlorine.—It is an irritant and heavy gas and the disinfectant and deodorant properties depend on its affinity for hydrogen. Therefore it is essential that a certain amount of moisture should be present. As compared with SO_2 its bleaching properties are more marked. It is prepared by the action of hydrochloric acid on chloride of lime. According to Delépine and Ransom chlorine generated in nascent state by thoroughly washing a room with a solution of bleaching powder (1 in 100) is more efficient as a disinfectant. Chlorine is usually used in the form of chloride of lime which should contain about 15 per cent of available chlorine. This chloride of lime is an unstable compound. For disinfecting purposes chlorine must always be used in excess. About eight ounces of the powder with three pints of water are required for a room ten feet square. Bleaching powder does not damage articles to any great extent.

Formaldehyde.—This is used as a gaseous disinfectant, the gas being liberated from tablets by heating in some special form of lamp, and has largely replaced sulphur of recent years. It may be readily generated by pouring formalin on permanganate of potash. The proportion of the two substances which gives the best results and the driest residue, is two parts of formalin to one part of permanganate. The method is effective, simple, rapid, and by virtue of the inexpensive apparatus required preferable to the older and more cumbersome methods. For a space of 2000 cubic feet 10 ounces of the permanganate and one pint of formalin are required, the reagents being mixed or added the one to the other in an ordinary galvanised iron pail. The crystals which are better crushed, are put in first, and then the formalin is poured on them. There is time for the operator to withdraw, and the period of disinfection should be six hours. Heat and moisture are essential for efficient disinfection. From 60 to 70 degrees F. is a proper temperature, while it is well to render the air of the room moist in a dry country.*

Practical Methods of Disinfection.

The chief point to be aimed at is the efficiency of the disinfectants used and to see that there is nothing to disturb the efficient working. Presence of albuminous matter, nature of the materials to be disinfected and the character of the water for diluting the disinfectant fluid are important factors to be attended to. Hard water considerably interferes with the property of the disinfectants, and a pure and soft water should always be used. Disinfectants again seem to act better at a high temperature than at a low one, and is more powerful when in a state of emulsion than when in solution. Practical disinfection includes disinfection of sick room, inhabited rooms, persons, clothing, effete materials, dead bodies, bathroom, &c.

---

* Reviews of Recent Advances in Tropical Medicine.

1. Spraying.—If proper apparatus cannot be had a disinfecting inspector with two men should go with a cart containing gunny bags, an Equifex sprayer and disinfectants, and engage themselves as follows :

(1) The bedding, clothes, towels, &c., should be packed in the bags in a previously disinfected place, sealed, and sent to the disinfecting station for disinfection by steam.

(2) Fill the disinfector and spray with the disinfectant the walls, floors, ceiling, &c., crevices and corners ; in fact all receptacles for dirt should be thoroughly attended to. Walls should be scraped before spraying. A practical point is to spray the walls from below upwards to prevent the solution running down the wall and producing discoloration.

(3) Pictures and ornaments should be wiped with clean muslin moistened with disinfectant solution. They may be sprayed and subsequently wiped dry.

(4) Bathrooms, spittoons, water closets, cups and dishes, &c., used by the patient should also be disinfected.

(5) Drains should be cleaned thoroughly and treated with a 5 per cent solution of crude carbolic acid and all damp places should be sprinkled over with Calvert's carbolic acid powder.

(6) Disinfectors should repeat the process over again and then wash themselves.

The disadvantage of this method is the discomfort experienced by the disinfectors in thoroughly carring out the work. Disinfectors should wear either cotton or water-proof (mackintosh) coats whilst at work. Solutions of mercuric chloride 1 in 1000, chinosol 1 in 1200, formalin 1 in 40, carbolic acid, and lysol are efficient for spray.

The best time to disinfect a room is when the patient is dead or convalescent.

2. **Fumigation.**—It is not of much value and may be used as a subsidiary procedure after spraying.

3. **Washing.**—The walls, ceilings, &c., may be washed with a solution of corrosive sublimate (1 in 5000), chloride of lime (1 in 100), or hypochloride of lime (1 per cent).

When a case of infectious disease occurs in the absence of a competent medical adviser, the following simple rules should be observed* :—

1. Whenever a steam disinfector is available, all articles of bedding, carpets, hangings, etc., which are not likely to be injured by steam should be sent to the disinfecting station.

2. When a steam disinfector is not available, cotton and linen articles should be boiled for half an hour. Blankets and other woollen articles and coir fibre should be soaked for two hours in Izal solution. Cloth articles should be sprayed with a five per cent solution of pure carbolic acid in water and exposed to the sun for three or four days. Leather articles should be sponged with one per cent formalin solution.

3. Feeding and cooking utensils should be boiled for 15 minutes. Immersion in a 20 per cent *hot* solution of washing soda suffices, however, for most infectious diseases, but it will not serve in cases of infection by the *tubercle bacillus.* Table knives, mounted forks and similar articles which are damaged by high temperatures should be soaked for two hours in an one per cent solution of formalin.

4. The walls of the rooms occupied by the patient should be scraped and re-limewashed.

5. Furniture, floors and woodwork should be scrubbed with hot water and soap.

6. Earthen floors should be saturated with a disinfectant preparation, either a solution of mercuric chloride, 1 part in 1,000 of water, or kerosine emulsion with cyanide will serve.

7. The woodwork of the latrine used by the patient should be scrubbed with mercuric chloride solution and the floor saturated with the same solution.

---

* Lukis and Blackham : Tropical Hygiene.

CHAPTER XIX.

INFECTIOUS DISEASES.

MALARIA.

Malaria is a specific infectious disease caused by a sporozoon parasite and carried from man to man by the agency of certain species of mosquito. In man they inhabit the red blood corpuscles, giving rise to pyrexia, exhibiting a characteristic periodicity, accompanied by anæmia and enlargement of the spleen.

The 'malarial theorem,' as Sir Ronald Ross calls it, may be stated as follows: Malaria in man is due to a minute parasite (protozoa) which lives and multiplies in the blood passing its trophic phase within the red blood corpuscles. The parasites are introduced into men only by the bites of mosquitoes of the sub-family *Anophelinæ* of the *Culicidæ*, which have themselves become infected by sucking the blood of infected persons containing the gametes of the malarial parasite.

Geographical Distribution.—Malaria is a wide-spread disease. Broadly speaking it occurs with increasing frequency and intensity as the Equator is approached, and is more prevalent in tropical and sub-tropical countries than in those situated in the temperate zone. It is on the decrease in Europe, and its endemic areas are limited. In Asia it has a much more extensive distribution than Europe. It is found with varying degrees of frequency and intensity throughout India, Indo-China, Southern China, Burmah, Ceylon, the Malay Peninsula, &c. It is more prevalent in Lower Bengal and Assam than in other parts of India. In tropical Africa malaria is at its worst form, and the West Coast of Africa is known to be the most malarious region in the whole world. Australia and Japan enjoy comparative immunity from this disease. According to Leslie in an ordinary year death from malaria is about 5 per 1000 in India.

Race incidence and acquired immunity.—The question whether immunity is possible may be answered in the words of Manson as "yes" and "no". It is often asserted that one attack gives immunity, but this is not always so, as relapses very often occur. Occasionally, however, one severe attack, or repeated attacks give certain amount of protection to an individual for the rest of his life. On the other hand, it is very common to find old inhabitants of malarial districts enjoying the best of health and perfect immunity. New comers to India are more susceptible to attacks of malaria than old residents. Some races and certain individuals are however less susceptible to malarial influences than others, but very few are absolutely immune. The Chinese, the Malays, and some other dark-skinned races also appear to enjoy a comparative immunity—an immunity considerably less pronounced however than that enjoyed by the African and West Indian Negro. Koch has shown with certain amount of precision that the apparent immunity of the Negroes, Malanesians and other dark-skinned races are due to repeated and persistent infection in childhood. He observes that the protection of infected children becomes less with each additional year until adult life when the person becomes free of the parasite and immunity is established.

Etiology.—Factors which predispose to malaria are the conditions which favour the growth and spread of the anopheline mosquito.

(1) *Season.*—It should be observed that mosquitoes require a comparatively high atmospheric temperature to develop ; consequently malaria abounds chiefly in warmer latitudes. Malaria is to some extent a seasonal disease. In temperate climate it is prevalent during summer. In India, the period of maximum intensity is from October to December ; it is next most common during the rains lasting from the middle of June to early October ; it is less prevalent during the dry first half of the year.

(2) *Local Conditions.*—Malaria is for the most part a rural disease, and towns are much less malarial than

villages. Calcutta, for instance, is comparatively free from malaria than its surrounding area. Malaria tends to follow the distribution of heavy rainfall. Intermittent and moderate rainfall—provided there is sufficient water collected for oviposition—is more favourable for the breeding of mosquitoes. Roughly it may be stated that malaria is more prevalent in India during the periods of heavy monsoon rains, particularly in the places and localities where the drainage is inefficient or in any way obstructed.

(3) *Soil.*—There is no evidence to show that malaria is in any way related to the mineral constituents of the soil. Soil only plays an indirect part in the etiology of malaria by affording facilities for collection of water wherein mosquitoes can breed. Loose, porous, sandy, alluvial soils, deep loamy marshy lands, with a substratum of clay affording capacity for the retention of water, and level countries presenting physical obstacle to underground drainage, are most favourable during a moderately high range of temperature, to the development of malaria (Hehir). It is a known fact that high level of ground water causes pools which would otherwise remain dry and favours breeding of mosquitoes. On the other hand persistently low ground water level, say 15 to 20 feet, is unfavourable to malaria.

(4) *Marshes, Tanks, &c.*—Water being essential for the breeding of mosquitoes, inhabited areas close to swamps, marshes, *jheels*, ponds, excavations (*dobás*), paddy-fields, &c., are as a rule malarious. Ravines are always unhealthy, specially when covered with trees and plants. Villages adjoining irrigation canals and ditches are equally responsible as sources of anophelines. Canals and ditches not only breed mosquitoes but make the surounding area sodden and damp. Ditches of whatever description, unless properly taken care of, are productive of malaria, particularly when they are drying up.

(5) *Rice and Jute Cultivations.*—A rice field may be regarded as a type of swamp or marsh. In India without adequate subsoil drainage rice cultivation is injurious to the health of the cultivators. In certain districts of Bengal where cultivation of jute is carried on, facilities for breeding of mosquitoes are afforded during the process of retting of the

stalks in pools and ponds of stagnant water. In fact these factors contribute largely to the high prevalence of malaria in India. In endemic areas it might be justifiable to condemn their cultivation, but in a place where millions depend on rice crops for their very existence, a rigid attitude towards rice cultivation cannot be adopted. But, whenever possible, rice cultivation should be prohibited in densely populated places.

(6) *Railway in relation to Malaria.*—There is a good deal of truth in the popular belief that construction of railways in India has helped to maintain and disseminate malaria, and some districts previously healthy have been made badly malarious by railway works. This acts in two ways: (i) By the formation of burrow pits, which when converted into stagnant pools and marshes become breeding places for mosquitoes, and (ii) by embankments, which cause obstruction to natural drainage. (See also page 79.)

(7) *Predisposing Causes.*—Anything which lowers the natural resisting power—deficient food, excessive labour, chills produced by sudden fall of temperature, occupation of dark and insanitary houses which usually harbour mosquitoes, trying damp heat, &c.,—predisposes one to attacks of malaria.

The Parasite.—The cause of malaria is a sporozoon parasite, of which there are three species. These different species have been classified according to (i) the duration of their respective life cycles inside the human body; (ii) their morphological characters; (iii) the clinical phenomena they give rise to; and (iv) the results of inoculation experiments.

The different parasites, and the diseases they give rise to, may be broadly divided into two groups—the *benign* and the *malignant*. Morphologically these are distinguished by the fact that the benign parasites never form crescent bodies, the malignant parasites, or at least the sub-tertian, form crescents. Clinically benign parasites rarely give rise to pernicious attacks, whereas the malignant parasites frequently do. The different kinds of the parasites may be arranged as follows:

Benign	Quartan Tertian	Do not form crescents.

Malignant	Subtertian :	Form crescents.
	Quotidian—pigmented	Supposed to form crescents.
	Quotidian—unpigmented	

That the three species of malarial parasites—the benign tertian, the quartan and the malignant are distinct species, is supported by the fact that infection with one type gives rise to the corresponding type of the parasite and no other in the individual.

The malarial organism exists in nature as a parasite in man and in certain species of mosquitoes. The parasites are found in the salivary glands of the mosquitoes in fine fusiform bodies, and vary in size during development, being in man from 1 to 8 μ, in the mosquito from 8 to 40 μ. In the human host it develops within the red blood cell and possesses amœboid movement which enables it to change its shape and position.

The parasite possesses two cycles of development : *asexual* and *sexual*. By the asexual method it matures and propagates within the human host. By the other in order to attain maturity after having partially developed in man it enters a second host—a certain species of mosquito. This sexual cycle ensures perpetuation of the parasite, as it is by this means the parasite can only pass from man to man.

The Asexual or Human phase of the Parasite.—If the blood of a patient be examined during an attack of malarial fever, *e.g.* of the benign tertian variety, shortly after the rigor, the parasite may be recognised as a pale somewhat undefined disc of protoplasm within the red blood cell. Scattered through this pale body are a number of black or reddish black particles called *hæmozoin*. By making a series of fresh observations at short serial intervals other changes will also be found to occur in this disc of pigmented protoplasm and the parasite will be seen to grow at the expense of the corpuscle. The hæmozoin groups concentrate into one or two larger and more or less central blocks around which the pale protoplasm of the parasite arranges itself into minute segments which finally appear as well-defined spherules. At this time the blood corpuscles break down and the spherules fall apart and become free in the plasma. The phagocytes however, absorb the hæmozoin and many of the spherules, but some escape them, attack fresh red corpuscles and start the cycle anew. The parasite shows active amœboid movement inside these newly infected red cells and grows at the expense of the hæmoglobin which it assimilates and converts into the pale protoplasmic material constituting the mass of the parasites.

The *melanin* or the colouring granules then pass into the blood stream and thence by the white blood cells to the tissues producing darkening of the skin and other organs.

The Sexual or Mosquito Cycle.—In the sexual or exogenous cycle some of these spores develop into male and female gametes in the red cell. If the patient is now bitten by a mosquito it will abstract the parasite which passes into its stomach and the true sexual life then begins. By the union of male and female gametes a zygote is produced which burrows into the stomach walls of the mosquito and grows there forming a wormlike body packed with sporozoites when it can be seen with an ordinary lens. These sporozoites escape and find their way into the salivary glands of the mosquito whence they reach human beings. These spores then proceed to attack the red blood corpuscles and start the malarial cycle. Some of the spores however enter the ovary of the mosquito and infect the eggs, so that these young ones harbour the parasite and are thus able to confer the disease without having sucked the blood of an infected person.

In the absence of sexual reproduction the parasites after sometime die out owing to the exhaustion of the reproductive power. This is what happens when the patient is given quinine and the young ones which would eventually have given rise to sexual forms are destroyed.

Prevention.—In no disease is it more true that prevention is better than cure than in the case of malaria, for, although it is easy to cut short an attack yet it is difficult to completely eradicate the infection from the system (Rogers). From what has been said with regard to the etiology of malaria it is reasonable to make the following propositions :

(1) were all mosquitoes exterminated malaria would cease ;

(2) were all persons protected against the bites of mosquitoes no malarial infection would arise ;

(3) were all existing cases of malarial infection cured then malarial disease will be exterminated.

As corollaries to these Hehir draws the following conclusions :

(1) If mosquitoes can be diminished or prevented from attacking man the chances of dissemination of malaria can be reduced.

(2) If cases of malarial infection are lessened in number the chances of communicating the disease from man to man by anophelines are reduced.

The basis of malaria prophylaxis depends upon the fact that particular species of mosquitoes are indispensible for the propagation of parasites, and that in nature the parasites occur in both hosts, *viz.*, man and mosquito, and so far as is known nowhere else. Preventive measures are therefore founded on these facts, and have for their object (1) the destruction of the insect host, (2) the prevention of the transference of the parasites from one host to another, and (3) the destruction of the parasites in the blood of man.

The methods of prophylaxis may be considered under the following heads :—

A. Protection against mosquitoes by

(*a*) mosquito-proof houses,
(*b*) personal protection :
  (i) mosquito nets,
  (ii) punkhas and fans,
  (iii) mosquito-proof clothes,
  (iv) culicides,
  (v) culifuges.

B. Attack on mosquitoes and their larvæ.
  (*a*) Permanent measures.
  (*b*) Annual measures.
  (*c*) Larvicides
    (i) use of chemicals,
    (ii) cultivation of fish,
    (iii) dragon-fly larvæ,
    (iv) frogs, lizards, spiders, &c.

C. Quinine—
  (*a*) For the eradication from population.
  (*b*) Prophylaxis.

D. Prophylaxis in villages.

A. Protection against Mosqitoes:

A greater part of prophylaxis against malaria is embraced in protecting ourselves from mosquito bites. The measures adopted are:

(*a*) *Mosquito-proof Houses.*—Protection of the whole house or parts of house with wire gauze has long been used in South America, and is employed against yellow fever and malaria in Panama. This appears to be an ideal method of excluding mosquito, but the cost is rather prohibitive, and excepting perhaps for some big houses and bungalows it cannot be used universally. This is after all a mechanical protection and the occupant is open to infection as soon as he comes out of the house. In the absence of actual mosquito-proof houses, the doors and windows may profitably be kept closed in India by mulmul and door *chicks* which should be kept carefully closed all day.

(*b*) *Personal Protection:*

(i) *Mosquito netting.*—As early as 1828 Ansley recommended the use of mosquito net as a protection against malaria. A mosquito net is of most practical value, and according to Ross a jealous use of a net reduces the chances of infection anywhere by 90 per cent. It acts by protecting people from contracting malaria from the bites of infected mosquitoes and by preventing sufferers from the disease from becoming a source of infection to others. Mosquito nets are fairly cheap, and may with advantage be used by all classes.

(ii) *Punkhas and fans* are useful in driving away mosquitoes.

(iii) *Mosquito-proof Clothes.*— Suitable clothing often affords protection against bites. It should be noted that mosquitoes can bite through thin cotton garments. It is advisable, therefore, to use thick woolen garments especially during the malaria season. Legs and ankles being the favourite hunting places of the mosquito and the sandfly, socks should be of thick wool and boots preferred to shoes.

(iv) *Culicides* are agents used to kill mosquitoes. Various fumes, gases, and odours kill adult mosquitoes, and of these sulphur fumes, formaldehyde vapour, smoke of the leaves of *neem* (*Azadirachta indica*), crysanthemum and pyrethrum powder, and of odours—menthol, camphor, turpentine, *loban* (benzoin), &c., are generally used.

(v) *Culifuges* are agents that prevent the bites of mosquitoes. Oil of eucalyptus, oil of rosemary, lemon grass oil and essential oils generally, are used to keep off mosquitoes, and they are commonly applied to the skin of face, hands, ankles and other exposed parts of the body. Of all these, oil of lemon grass is in great favour as it has a pleasant smell and is comparatively cheap and harmless. Kerosine oil applied with lanoline, or pure oil sprinkled about the bed room also keeps off mosquitoes. These applications are only of temporary benefit, for, as soon as the volatile part of the oil, essence or ointment has evaporated mosquitoes will unhesitatingly begin their attack, and therefore they are useless after about half an hour or so.

Certain colours like navy blue, dark red, reddish brown and black are more attractive to mosquitoes.

B. Attack on the Mosquitoes and their Larvæ:

(*a*) *Permanent Measures.*—These consist in dealing with the breeding grounds once for all. They include proper drainage, filling up of pools and dirty tanks, rectification of water courses, &c.

One of the primary measures for the reduction of malaria is efficient drainage, and this is of greater importance in India than anywhere else. The question of permanent reduction is to do away with the *Kutcha* drains, which are in reality shallow open trenches where anophelines breed. *Pucca* surface drainage is an important permanent antimalarial measure. Drainage schemes when carried out on a large scale takes sometime before they indicate any distinct influence for the better, but well-devised drainage when intelligently carried out would eventually subdue malarial fever. In all drainage undertakings the planning should be made during the rains, as then the collection could be better estimated and regulated. Being the most easy and economical way, marshes, swamps, *jheels*, &c., should be drained in some water-course. Newly irrigated districts are always malarious, it is therefore necessary in all irrigation works to have adequate subsoil water-drainage. It is said that the existence of irrigation in the Lahore Cantonment was the cause of failure of the anti-malarial measures carried out by James and Christophers. Tanks, large or small, burrow pits, garden cisterns and collection of surface water generally, forming breeding places of mosquitoes, should be filled up with dry refuse.

(*b*) *Annual Measures.*—When marshes or other collections of water cannot be dealt with permanently by drainage or other means and for small operations, annual measures may be of great value in some districts. These are best performed by what are called "mosquito brigades." They may usefully be applied to a great variety of places in India—towns, collections of villages, cantonments, jails and all large industrial works and factories. Considering the fact that aggregation of large gangs of labourers on engineering works, famine relief works, railway constructions, irrigation canal works, road making, &c., often help in the formation of breeding grounds of anophelines, one would emphasize the necessity of their employment under such conditions. Half-a-dozen coolies under one headman and a few gangs of such men working efficiently can prevent much of the malaria. The duties of mosquito brigade men are* :—

(1) To visit regularly once a week the compound of every house and destroy every pool of water which can harbour mosquito larvæ : (2) to cover with a layer of kerosine oil and pesterine every collection of water which is too large to be destroyed : (3) to remove all broken tins, pots, bottles, etc., which can contain water and harbour larvæ : (4) to instruct the inhabitants in the recognition of mosquito larvæ and in the methods of destroying them : (5) to see that bye-laws requiring all fixed receptacles of water, cesspools, etc., to be made mosquito-proof, are carried out, and to bring to the notice of the superintendent any house-holder in whose premises mosquito larvæ are frequently found : (6) during the rains to drain off quickly all superficial collections of water which can last sufficiently long enough to become breeding grounds of mosquitoes : (7) to endeavour to kill adult mosquitoes in houses, out-houses, and stables by fumigation with sulphur and other means : (8) to make observations as to the seasonal prevalence of mosquitoes, their habits, and every matter regarding which increased knowledge might aid in the extermination of these insects.

(c) *Larvicides* :—

(i) *Chemicals*.—Petroleum and all oils act by intercepting the air from the larvæ requiring oxygen. The stratum of oil prevents interchange of air by the larvæ and by obstructing the breathing tubes causes them to be drowned.

Kerosine diffuses more readily. A three-gallon tinful of oil is enough for an area of 10,000 square yards. Equal parts of kerosine oil and pesterine appear to be better than pure kerosine. This combination has been extensively and successfully used in Ismalia, Cairo, Panama Canal Zone, &c. The application is best done by means of an ordinary garden spray. *Pesterine* is crude petroleum sold in 4-gallon tins at Re. 1/4/- per tin.

Major Fry found that a combination of chlorinated lime with crude petroleum applied along the edges of a pool not only killed the larvæ but prevented the mosquitoes from coming to it to lay their eggs.

---

* Major James : Malarial Fevers, Third Edition.

The application of chemicals like kerosine oil and crude petroleum is not always followed by the extermination of the mosquito larvæ. In order to be effective it has to be repeated very often, which, besides proving a nuisance, has the disadvantage of being washed away after a heavy shower. Being poisonous, the application kills the small fish, snails, and other animals by nature inimical to mosquito larvæ. In fact it does more harm than good. In villages where men and cattle use any collection of water for drinking purposes, to scatter poison broadcast is not unattended with some danger.

(ii) *Cultivation of Fish.*—It has been suggested that existence of "millions" around the islands of Bermuda and Barbadoes is the cause of absence of malaria and mosquitoes in those places, and "Barbadoes millions" were imported for the purpose of checking malaria in India. The result was however disappointing, and it has been pointed out that the indigenous fish, *Haplochilus panchax*, is superior to the foreign species in battling with the mosquito larvæ. Haplochilus is not only more active and agile but more hardy than millions, and bulk for bulk can clear a great deal more of living larvæ than the millions. They fare well in shallow water, prosper and multiply by the edges of the tanks in among the weeds. The following are some of the varieties[*] :—

Genus	Species	Local name
Haplochilus.	H. Panchax.	*Panchoke, Lal jhingra.*
Do.	H. Uncolatus.	*Piku.*
Trichogaster.	T. Fasciatus.	*Khalse, Khalas.*
Badis.	B. Badis.	*Chiri, Bhedo.*
Anabas.	A. Scandens.	*Koi, Kavoi.*
	Chela Agentea.	*Chilwa.*

The fishes selected should have the following characters :—

(1) They should be small in size.

---

[*] Sewell and Chaudhuri: Indian Fish of Proved Utility on Mosquito Destroyers.

(2) They should be hardy and should flourish both in shallow and deep waters.

(3) They should breed freely in confined water areas.

(4) They should be able to stand transport and handling.

(5) They should be able to escape all natural enemies including artificial contrivances of men to catch them.

(6) They should be absolutely worthless and insignificant as food.

Dragon fly larvæ and tadpoles also destroy mosquito larvæ. Bats, lizards, spiders, &c., are the enemies of adult mosquitoes.

C. Quinine.—Quinine has been used in the treatment of malaria and acts by destroying the parasites in the circulation. The following points have to be taken into consideration with regard to the administration of quinine in malaria :

(1) Its proper dose. (2) Time for administration. (3) The best salt of quinine, and the most soluble method of administration. (4) The best method for using it for prophylactic purposes. (5) The class of cases in which the use of quinine is inadmissible.

The principle aimed at in cinchonisation of its inhabitants in a malarial district is the extinction of malarial parasites from all infected persons ; but complete eradication of malaria from the human system by quinine takes a longer time than which is ordinarily followed. "To extirpate the parasite in a patient demands, let us say, four months assiduous cinchonisation and in very malarious towns a large percentage of the natives and nearly all the children may be infected. To deal with these will require a heavy annual expenditure for medical attendants and quinine with examination immigrants."*

As a prophylactic there are various methods of administering quinine but it should always be given regularly. The best form is to take five grains of the salt every day (preferably in the evening) during the malarial season. The prophylactic use of quinine is now adopted practically in all jails and among all troops. Europeans living in endemic malarial districts also take quinine regularly as a prophylactic; but for the use of the general population certain difficulties are met with:

---

* Ross in Albutt's System of Medicine.

(1) A very large number of Indian patients have a strong prejudice against quinine.

(2) An Indian regards a medicine as something to be taken only when ill. He has no knowledge of prophylaxis and it is often impossible to persuade him to take medicine for that purpose.

(3) It is extremely difficult to administer quinine to children, particularly Indian children, who are the chief disseminators of malaria.

Therefore for quinine prophylaxis to be successful in any given area four things would have to be accomplished:

(1) Remove the prejudices of the public against quinine.

(2) Impress the idea that prevention is better than cure.

(3) Use some palatable form of quinine for administration to children. Euquinine or tannate of quinine are comparatively tasteless.

(4) It must be given so as to be quickly absorbed by the stomach otherwise there would be a failure. The best form of administration is in solution.

D. Prophylaxis in Villages.—The reduction or suppression of malaria in villages is of vital importance in as much as four-fifths of Indian malaria occurs in villages. Although the broad principles for preventing the disease are the same whether one has to deal with cities, towns, cantonments and villages yet the details by which these are carried out are not identical. The mass of people living in the villages are not only poor but ignorant of the very rudiments of sanitation. Measures, therefore, to prevent mosquitoes from biting by the use of mosquito-proof houses, fans or punkhas, or culicides cannot be so freely and universally used. Reduction can only be effected by case-reduction in villages and by measures which will reduce the number of anophelines in and around them. It is therefore necessary that the *rationale* of our present-day prophylactic measures of malaria should be widely circulated and made known. In every village, persons capable of understanding the primary principles of prevention should be held responsible for the carrying out of preventive measures, and villagers should be impressed with their importance through them. *Travelling dispensaries* in charge of medical officers will serve a very useful purpose in distributing quinine and giving relief to villagers, especially during the malarial season. Major Fry suggests that the people must be taught to help themselves and once they could be made to realise what "watertidiness" consists in, elimination of the offending larvæ will be a comparatively easy task. In a mill close to Calcutta he could make the people realise the true significance of watertidiness, where water was not allowed to be collected in rejected *handis* and *chatties*, broken tin boxes, &c., and shallow pools were filled up. The results were most gratifying in that the incidence of malaria was almost abolished. Instructions regarding the main facts connected with the malaria should be given by lectures and by leaflets in vernacular. The elementary principles of sanitation may profitably be incorporated in text-books for children. Besides the above the following special measures recommended by Hehir are of great value :—

(1) the treatment of all cases of malarial fever and malarial enlargement of the spleen with quinine issued gratis ;

(2) the making of surface drains (even *katcha* drains) properly graded for removing rain water and refuse water generally ;

(3) covering of all sources of water supply with some mosquito-proof material ;

(4) the filling up of all burrow pits and excavations in and around villages for a distance of at least 100 yards ;

(5) the prevention of all cultivation within this 100-yard limit and of wet cultivation within 200 yards ;

(6) the keeping of this 100-yard area and the interior of the village free from mosquito larvæ.

KALA-AZAR.

Manson describes Kala-azar as an infective disease characterised by chronicity, irregular fever, enlargement of the spleen and often of the liver, the presence of the "Leishman body" in these and other organs, emaciation, anæmia, frequently a peculiar hyper-pigmentation of the skin and a high mortality.

Under the name of Burdwan fever the disease was known in Lower Bengal in the early fifties of the last century, and it was known to exist in Assam from as far back as 1869. In 1881 it broke out in an epidemic form at the foot of the hills just to the east of the Bramhaputra. The earliest record of the disease is by Clarke who in the Assam Sanitary Report for 1882 described it as a severe form of malaria cachexia.

Etiology.—In 1903 Sir William Leishman first described the parasite of Kala-azar, and about the same time Donovan observed similar bodies in the spleen of patients dying of chronic fever in Madras. These parasites have been named after them and are known as "Leishman-Donovan bodies." They are small round or oval bodies about the size of a blood plate. In each parasite an oval macro and a rod-shaped micro-nucleus and a capsule could be differentiated. Most of the parasites are free and a few are aggregated inside leucocytes. The distribution of the parasite in the body is rather general, but are most numerous in the spleen, bone-marrow, and liver. It also occurs in the blood though in small numbers, being found there both in polymorphonuclear and mononuclear leucocytes, and very rarely in the red corpuscles. In the blood it is in greatest abundance towards the termination of the case, especially during fever, and when intestinal symptoms are present (Donovan). Rogers discovered the flagellated stage of the parasite suggesting that the organism belongs to the genus Herpetomonus.

The disease spreads by human intercourse, and unlike malaria it shows a predilection for the acclimatised,—the natives of the place and the old residents are said to suffer most. Both sexes and all ages are equally affected and no occupation is bar to the disease. According to Rogers the majority of cases occur during the cold season.

Mode of Transmission.—This is still doubtful. Patton finding flagellated form of Leishman-Donovan bodies in the gut of the bed-bug (*Cimex rotundatus*) believes that the transmission of kala-azar takes place through common bed-bug. Donovan, however, asserts that Patton's view concerning the transmission of kala-azar by bed-bugs cannot be accepted in its entirety, that is to say the *herpetomonads* he found in the gut contents of Cimex rotundatus may be only the natural commensals of this insect.

Prophylaxis.—According to Rogers it is now certain that this awful scourge can be robbed of most of its terrors whenever it is possible fully to carry out segregation measures. This isolation should be followed by thorough disinfection of infected clothes, houses, beddings, fomites. Destruction of all forms of insects, specially bed-bugs, in infected houses is the only important measure in the present state of our knowledge.

ENTERIC FEVER.

Enteric fever is widely distributed all over the world particularly in India. It is more common among the Europeans, especially among the new comers.

Etiology.—The disease is caused by a specific micro-organism called the Eberth-Gaffky bacillus. It is a short, thick, flagellated, motile bacillus with rounded ends and in appearance not unlike the tubercle bacillus. It can be isolated in autopsy from the spleen, mesenteric glands and gall bladder. The growth of the bacillus in various culture media is of some value. In broth it produces uniform turbidity without sediment. On agar the colony has a delicate transparent appearance with crenated edges. When planted by stab culture growth takes place along the line of the needle. Absence of oxygen therefore does not inhibit its growth. The bacillus is best stained by Loffler's methylene blue. It thrives in milk and is said to multiply for a short time in sterile water. It resists drying for months and may live for many weeks in ice. In the upper layers of the soil it retains its vitality for months. Likewise it also retains its vitality for weeks when mixed with sand or earth and dried. This mode of spread of the disease through dust demands more careful attention.

Mode of Infection.—This may be direct or indirect.

(*a*) *Directly* it is communicated to the attendants for want of proper precautions in handling patients or their excreta. Infection sometimes clings to the bed of the typhoid patient and successive patients seem to get the attack when occupying the same bed.

(*b*) *Indirectly* it is communicated through water infection. Many wide-spread epidemics are traced to this cause. Water of tanks or wells once polluted will spread the disease which becomes a scourge to the locality. In India the chief source of infection is through contaminated milk and water.

Food is also an important vehicle of infection.

Milk very often contains typhoid bacilli when mixed with polluted tank or well water. The disease may also be transmitted by salads, ice-cream, etc., or by eating celery or uncooked vegetables which have grown on soil on which infected materials have been used as fertilisers. Flies alternately visited and fed on infected fæcal matter and on food are also a great source of danger.

There is yet another source of infection. It has been known for some years that typhoid bacilli could be discovered in the urine and stools of persons who had suffered from the disease for a considerable time after recovery. This has been very minutely investigated by German hygienists, and instances are brought to light in which persons who sometime before suffered from an attack had typhoid bacilli in their stools. Investigations of German bacteriologists brought another fact to light, that it was not simply persons previously affected with typhoid fever whose excreta contained the bacilli. Such persons who harbour typhoid bacilli in their excreta are called "carriers," and the German authorities speak of *acute* carriers who have never had typhoid but who for a short time have the organisms in their exereta. *Chronic* carriers are those who have had typhoid fever and their excreta contain bacillus for months or years after attack. A bacillus carrier in charge of a kitchen, dairy, or bakery is a much more dangerous person than a carrier who has nothing to do with the preparation of food or milk. Sir David Semple mentions a case where a man had been a bacilli carrier for nearly ten years.

Season.—In temperate climate the disease is more prevalent in autumn and early winter. In India the disease is equally prevalent all the year round, and in Bengal it shows its maximum in the dry hot months. The majority of cases with the Europeans here occur in dry cold and hot seasons.

Age, Sex, &c.—Both sexes and all classes and races are equally affected. According to Rogers, typhoid among Europeans born and bred in the tropics is four times as great amongst children under 15 and four times less among adults over 25, as compared with temperate climates. It should be remembered that those who are exposed to infection do not always take the disease. Some families are more susceptible than others. It is said that one attack gives immunity although two attacks within a year have also been recorded. Within a short time after recovery the immune substances disappear from the blood but the relative immunity lasts for a long time, frequently for life.

Prevention.—An early diagnosis of the case followed by isolation or segregation of the sick and thorough disinfection of all discharges are of primary importance. All conditions of defective hygiene should be remedied and suspected water or milk boiled. Stools, urine and other discharges should be received in vessels containing strong disinfectants and should either be deeply trenched or cremated along with soiled rags, &c. Soiled clothes should be placed in a strong solution of carbolic acid and then boiled. Rigid methods of cleanliness by attendants should be adhered to.

It is almost impossible to lay down any rules for the management of the carriers excepting isolation, cleanliness, disinfection of stools and urine, and selection of employment which gives no opportunity of infecting other people. There is no safe and reliable method by which a carrier can be free from infection.

Protective Inoculation.—As a protective inoculation against typhoid fever the vaccine was first prepared by Wright and Semple at Netley in 1896. This vaccine resembles Haffkine's-anti-plague prophylactic in that it contains dead typhoid bacilli and their toxins. The bacilli are grown in buillon under strict aseptic conditions. The initial dose consists of 500 to 1000 millions, the second of double the quantity.

Two inoculations are made at an interval of ten days. The first inoculation always causes a certain amount of febrile disturbance with headache and general aching. The experiences of the Boer War show that in this an important prophylactic method has been discovered. According to Wright's statistics the case incidence amongst the inoculated was only 2·25 per cent with a mortality of 12 per cent against 5·75 per cent and 21 per cent respectively amongst the uninoculated.

PLAGUE.

Plague is an acute infectious disease caused by a specific bacillus and characterised by inflammation of the lymphatic glands, sometimes by pneumonia or septicæmia.

The earliest historical record of plague is described by Rufus of Ephesus as a fatal form of bubo which occured in Lybia, Egypt and Syria about the third and the beginning of the second century B.C. The first authentic account of plague refers to the latter half of the 6th century A. D., which lasted for fifty to sixty years and was known as the plague of Justinian. From that time there was no other epidemic till the Black Death of the 14th century. In the 15th century there were outbreaks in many parts of Europe chiefly imported from the East. The first outbreak of plague recorded in India was in 1612 by Emperor Jahangir. In 1815 bubonic plague broke out in Kutch, and then spread to Sindh and Guzerat and lasted till 1821. In 1823 it broke out in the Kumaon Hills on the west of Nepal and was known as *Mahamari.* In 1836 a fresh outbreak occured in the town of Pali in Rajputana spreading to Jodhpur and Marwar and continued till 1838. This is known as the Pali plague.

In 1871 plague appeared in endemic form in the south-west of China in the province of Yunan, and probably following the trade route it spread to Pakoi on the Gulf of Tonquin. In February 1894 it had extended to Canton and in April it appeared in Hong-Kong and many other places in the southern provinces of the Chinese Empire.

In 1896 it broke out in Bombay having probably been imported from Hong-Kong and thence it spread to Calcutta, and subsequently throughout India where it still prevails. The total number of deaths recorded from this cause in India for thirteen years (1897—1909) amounted to 6,133,476.

Six varieties of plague are commonly met with ; they are bubonic, pneumonic, septicæmic, intestinal, pestis ambulance and pestis minor. Of these the bubonic and the pneumonic forms are most common.

The Bacillus.—The plague bacillus was first discovered by Yersin and Kitasato during the Hong-Kong outbreak in 1894. It is a short oval bacillus with rounded or square-cut ends occurring singly or in dumb-bells and occasionally in chains ; it is non-motile and does not form spores. The bacilli are demonstrated from *post mortem* specimens or from punctures of infected glands. It stains easily with any of the ordinary aniline dyes : Loffler's methylene blue or very dilute carbol fuchsin. It is decolorised by Gram's method. In fresh specimens it shows a tendency to bipolar-stains—the ends taking up the stain more readily than the middle. The organism is aerobic, although it grows less readily under anaerobic conditions. Upon agar the colonies are small and rounded and in stab culture in gelatine it grows slowly along the track of the needle.

The bacillus is killed by heating for ten minutes at 62° to 65°C. and loses its virulence on drying. The German Plague Commission stated that the longest time the bacilli of infected materials remained active was eight days. In drinking water they die in three days, and in sterile water in eight days. Direct sunlight kills the organisms in three to four hours.

It is also present and in great abundance in the spleen, intestines, lungs, kidneys, liver and other viscera, and also, though in small numbers, in the blood. In the pneumonic type it is present in the sputum in enormous numbers ; it occurs also in the urine and fæces (Manson).

Modes of Entry.—Plague may enter the body in three ways : *viz.* by (1) inoculation, (2) inhalation, and(3) ingestion.

(1) *Inoculation.*—This is the most common mode of entry of the plague bacillus. It is not necessary that the

insect (rat flea) should inject the poison into the puncture every time it bites, but as it sucks the blood it is in the habit of depositing its fæces, and the irritation of the bite leads to scratching and the living bacilli in the fæcal deposit may thus be carried to some abrasion pre-existing or produced by the act of scratching.

People who walk about barefooted often have sores on their feet and toes which very often act as channels for infection. It is believed that this accounts for the immunity of children under one year of age who cannot scratch themselves.

(2) *Inhalation.*—This is the mode of entry of pneumonic and sometimes of septicæmic plague. Kitasato has demonstrated the presence of *bacillus pestis* in the dust from the walls of a room occupied by a plague patient. It appears that this mode of infection is common in India where the plague infected houses are generally ill-ventilated, dark and densely crowded.

(3) *Ingestion.*—There is no evidence that the ingestion of food causes plague, save infection through tonsils which may occur in cervical cases.

Means of Spread.—Plague is chiefly spread by contact directly with persons suffering from the disease, or with materials infected by such persons, or plague-stricken rats. The conclusions of the Indian Plague Commission may be quoted *in extenso*:

(1) Pneumonic plague is highly contagious. It is however rare (less than three per cent of all cases) and plays a very small part in the general spread of the disease.

(2) Bubonic plague in man is entirely dependent on the disease in the rat.

(3) The infection is conveyed from rat to rat and from rat to man solely by means of the rat flea.

(4) A case of bubonic plague in man is not in itself infectious.

(5) A large majority of plague cases occur singly in houses ; when more than one case occurs in a house the attacks are generally nearly simultaneous.

(6) Plague is usually conveyed from place to place by imported rat fleas which are carried by people on their persons or in their baggage. The human agent himself not infrequently escapes infection.

(7) Insanitary conditions have no relations to the occurence of plague except in so far that they favour infestations by rats.

(8) The non-epidemic season is bridged over by acute plague in the rat, accompanied by a few cases amongst human beings.

It is evident from the above that the Indian Plague Commission holds the view that rat flea (*Pulex cheopis*) is the prime agent in the conveyance of plague from rat to man. But Jardanski and Kladnitski have found that plague could be transmitted to animals by infected fleas (*Pulex irritans*), human fleas, &c., and bed bug (*Cimex lectularius*). Nuttall, on the other hand, observes that the evidence in favour of the flea hypothesis is worthless and cannot withstand scientific criticism. He holds that flies (*Musca domestica*) might be a source of danger in disseminating plague.*

Conditions favouring Plague.—Sir Thomas Fraser, the President of the Indian Plague Commission, holds that the most potent factors predisposing an outbreak of plague are overcrowding and insanitary conditions. But these alone are not sufficient, for even in the filthiest and overcrowded areas after an outbreak the plague dies out spontaneously. Insanitary conditions may be regarded only as a predisposing factor. Soil does not appear to harbour the germs. The Indian Plague Commission note that the bacillus has not been recovered from the soil by any trustworthy observer.

The universal experience of plague in India proves that houses into which the infection of plague has been imported whether by man or rats are infective; this infectivity being so marked that many of the officers who have had most experience of the disease have come to the conclusion that the principle source of the infection is to be found in the houses into which the infection of plague has been introduced.

---

* Nuttall: *Journal of Tropical Medicine*, March 1902.

The *bacillus pestis* has not been recovered from the mud or cowdung floors in India. The Plague Commission have shown that floors of cowdung if contaminated with *bacillus pestis* do not remain very infective for more than forty-eight hours and that floors of *chunam* cease to be infective in 24 hours.

Seasonal Prevalence.—Although it appears that season has some influence on the epidemicity of plague yet an epidemic may occur under any climatic condition. The first Bombay epidemic (1896) was at its highest in December, the second reached its highest in February, and the third in March. In Calcutta and Karachee epidemics occur during the hottest season and in Poona during the monsoon. But on the whole there is always a marked fall in the very hot months of May and June reaching its minimum in June or July, followed by a steady rise beginning in December.

Prevention.—As soon as the disease is recognised the sick should be isolated from the healthy, and infected clothes, articles and houses should be thoroughly disinfected. All insanitary conditions should be attended to and overcrowding prevented. Examination of passengers leaving the infected areas either by rail or steamer should be enforced, and whenever possible measures should be taken to prevent the inhabitants leaving the locality and thus disseminating the disease. If practicable the infected village or locality should be evacuated for about a month and inhabitants accomodated in temporarily built quarters or huts, while the infected house and those adjacent to them should be thoroughly disinfected. The safest and best form of disinfection is by fire, in fact with infected huts this is the only way of promptly stamping out the disease.

In cases of outbreaks it is important that one should remember the following points:—

(1) That an intimate relation exists between rat plague and human plague.

(2) That when conveyed to man it is communicable to others and to rats by means of expectoration, excreta and discharges from the buboes and other glandular swellings.

(3) That rat plague precedes human plague.

It follows therefore that the prevalence of plague depends on the density of the rat population, and according to Glen Liston the following conditions encourage their presence :

(1) Abundant food, (2) ample shelter, and (3) absence of enemies.

Proper measures therefore to stamp out plague from a town or village would be :

(1) Cleanliness and tidiness of the house, (2) houses kept free from food particles which would otherwise attract rats, and (3) discouragement of rats.

In view of the fact that the rat flea transmits the disease from rat to man, destruction of rats is a measure of great importance. Glen Liston has shown from laboratory experiments that a single pair of rats multiply to fifty pairs in course of a year. Hence it is important that a thorough and persistent attack on the rat population should be undertaken. This can be effectually carried out either by distribution of poison, or by offering remuneration for live rats and by distribution of rat traps—a system in vogue in some municipal towns, or by encouraging the keeping of cats in houses.

It is important that dead rats should not be touched by the hand but removed by a pair of forceps or sticks and cremated, and the infected spot should be saturated with disinfectants or treated by fire. Rat runs must be followed, dug up and obliterated. All rat holes should be stopped with broken glass, tar, Calvert's crude carbolic acid and then cemented.

Measures directed against rats.—(1) Rats and ratfleas are generally imported in grain sacks. All such sacks should therefore be opened in a closed paved area and rats and rat fleas immediately destroyed.

(2) Grain bags exported from an infected area should be thoroughly examined to pevent rats being sent with them.

(3) Basements of houses and floors of godowns of grain and forage should be concreted and made as ratproof as possible and rat traps should be systematically used for the destruction of rats.

(4) Rats cannot live without food and so a proper scavenging is essentially necessary. Greater attention to the organisation

of systems for the removal of refuse from towns and villages will be the first effective blow struck at the ubiquitous Indian rat.

(5) Habits of the people to live with their cattle and of storing all sorts of articles (grains, dals, &c.) among which rats find a comfortable home should be discouraged.

Antiplague Inoculation (Haffkine).—This consists of a cultivation of plague bacilli in bouillon, the bacilli having been killed and the solution sterilised by heat. The usual dose is 5 Cc. for an adult and is injected into the outer part of the upper arm. The injection is followed by constitutional disturbances lasting for about 24 hours. The immunity is established in about ten days of the inoculation and lasts for about six months, and often longer. The results of inoculation as attested by the Indian Plague Commission have been distinctly satisfactory, for although absolute protection is not afforded this method of treatment diminishes not only the total number of attacks amongst the inoculated but also the percentage of mortality amongst those attacked. The conclusions of the Commission were :

(1) Inoculation is harmless. (2) When given in the incubative stage, *i.e.* before the signs of plague are apparent, it has in many cases the power of aborting the disease. (3) Inoculation affords to all those inoculated a strong protection against attack by plague. (4) In the few cases where inoculated people are attacked a very large proportion recover.

The following table* gives the number of attacks and deaths from plague :—

	Population.	Attacks.	Deaths.	P. C. of deaths to population.
Uninoculated ...	8,001	487	350	4·3
Inoculated ...	1,584	36	20	1·2

---

* Standage : *Transactions of the Bombay Medical Congress*, 1909.

CHOLERA.

Cholera is an acute infectious epidemic disease characterised by profuse purging and vomiting of a colourless serous material, muscular cramps, supression of urine, algidity and collapse, the presence of a special bacterium in the intestines, and intestinal discharges and high mortality (Manson). It is endemic in certain river districts in India, *e.g.* Assam and the delta of the Ganges, and is principally a water-borne disease.

Etiology.—The following are the conditions necessary for a wide-spread epidemic of cholera :

(1) the presence of the microbe,

(2) a suitable medium and temperature for its growth outside the body,

(3) means of transport,

(4) a vehicle by which it can be diffused in a particular locality, and

(5) susceptibility to the infection.

(1) *The Virus.*—Koch in 1883 discovered in Egypt the comma bacillus supposed to be the cause of cholera. In 1884 he came to Calcutta and found the same bacillus in the stools of all the cholera patients then examined. It is a short, motile, organism about half the length and twice the thickness of the tubercle bacillus. It is slightly curved like a comma. It grows in an alkaline medium at a temperature from 30° to 40°C. but does not thrive in an acid one. Its growth is arrested below 15° or above 42°C., and a temperature over 50°C. kills the bacillus. It is aerobic, but is nevertheless capable of growing to some extent in the absence of oxygen. The primary source of the virus outside the regions where cholera is endemic is the intestinal discharges of persons suffering from or who had recently suffered from the disease. It has occasionally been detected in the vomited matters, and its presence in the vomit is to be accounted for by the contents of the intestines finding their way into the stomach. It is never present in the blood, liver, spleen, kidneys or mesenteric glands, although it has been observed in some instances in the gall bladder and the bile

ducts. It has also been found in the stools of convalescents up to fifty days after recovery.

(2) It is essential that the cholera vibrio must find some suitable medium outside the body for its growth. Such media are : (*a*) a soil polluted with organic matter specially excreta, (*b*) sewage polluted water, (*c*) milk and other food.

A suitable temperature is also necessary for its growth. Warmth is an important predisposing factor; on the other hand cold does not necessarily arrest an epidemic, as is evidenced by the various outbreaks in the Punjab where the temperature often comes down to zero. Epidemics generally occur in the late summer and autumn and subside with the advent of winter to appear again in the next summer. The maximum periods of epidemic cholera incidence in Bengal are in April, May and November and in the Punjab at the height of the rains.

(3) *Transport.*—Although atmospheric moisture is the carrier of the virus, it is not possible for the cholera germs to be transported to long distances by the *air*. Bryden maintains that its distribution over India extends as far as the moisture-laden monsoon winds carry it. But the *rains* supplied by the monsoons act in a different way. An insufficient rainfall favours the pollution of water-supply by washing down all surface filth, while a heavy downpour improves such sources of supply as rivers, streams, &c., by its flushing and cleansing effects. The principal means by which the virus is carried about are :

(*a*) *Human Intercourse.*—This is proved by the fact that cholera often follows the line of communication by river, road, rail or ship. Cabool for instance has always received the infection from India and has been the centre from which it has advanced westwards. When we remember that the diseases has been five times epidemic in Mauritius, and that on each occasion it broke out just after the arrival of vessels from India with the disease on board, and when we see it breaking out along the routes of pilgrims, following the lines of emigration we are led to conclude that human intercourse above all others is the important means by which cholera is transported from place to place.

(*b*) *Rivers.*—A polluted river may carry infection for very considerable distances to towns situated on its banks.

(4) The spread of cholera in a given locality is a question distinct from that of its transport. The most common sources of spread are :—

(*a*) *Drinking Water.*—When the virus finds its way into the general water-supply of a locality the disease becomes widely diffused. This is very common in villages where there is no proper water supply, and when the isolated tank or well becomes infected. This is shown by the fact that the spread of cholera has decreased by the introduction of a pure water supply. The average mortality of European troops at Fort William, Calcutta, was 20 per 1000 from 1826 to 1863. Since the introduction of filtered water up to the present time it has averaged 1 in 1000.

(*b*) *Milk*, &c.—Milk is not only a vehicle for diffusion but also a medium for growth. Many widespread epidemics may be traced to milk infection. *Insects* play an important part in the spread of the disease mechanically by settling on articles of food after having been in contact with infected materials. The common house fly acts as an active agent, and it has been shown that the germs are capable of living for at least 14 days in the fly.

Individual susceptibility counts for much in the matter of infection. Chronic alcoholism by causing gastro-intestinal catarrh predisposes to cholera.

Prevention.—An early diagnosis and notification are of primary importance. The prophylactic measures may be considered under the following heads :

I. Personal Prophylaxis :

(1) Correct any tendency to dyspepsia and derangement of the stomach.

(2) Promote the secretion of the gastric juice by keeping the stomach always full, an acid medium being hostile to the life and growth of the cholera germs.

(3) Avoid foods that may cause indigestion. Unripe

or over-ripe fruits, shellfish, or foods in a state of decomposition should be avoided.

(4) Avoid any food or drink while travelling by railway. Cold dishes, ice puddings, ice creams, &c., should be rejected and everything taken hot.

(5) Avoid bazar-made ærated waters. Freshly manufactured soda water should not be taken, and three or four days must be allowed for the carbonic acid to exert its destroying action on the comma bacillus.

(6) Purgatives particularly salines should be avoided.

(7) Water for drinking purposes and for washing dishes, &c., should as a rule be boiled. Filters are not to be relied on. Weak tea, lemon juice, *dahi* or butter milk, cocoanut water can be used with impunity.

(8) Diarrhœa during an epidemic should promptly be stopped.

Anti-cholera inoculation (Haffkine). — Haffkine prepares two vaccines of different strengths: (*a*) an *attenuated* virus in which the virulence of the organisms is diminished by passing a current of sterile air over the cultures; (*b*) an *exalted* virus in which the virulence has been increased by growth in the peritoneal cavity of a series of guinea pigs. The dose of each is 1Cc. The patient is first injected with the attenuated virus, then after a lapse of 3 to 5 days with the exalted one. The disadvantage of these preparations is that they have to be freshly prepared. Haffkine claims to have obtained great success by this method, but it is difficult to understand how the treatment can be expected to be efficacious seeing that in cholera the vibrios are in the intestinal canal and therefore in a way outside the tissues. They can therefore produce with impunity enormous quantities of toxins against which the bactericidal bodies in the blood have little or no neutralising power.

II. **General Prophylaxis.**—The following precautionary measures should be adopted for the safety of the community at large:

(1) All sources of water supply should be protected and all infected tanks and wells should be placed under guards

for at least a week and no one allowed to use their water under any circumstances.

(2) Persons from infected areas or houses should not be allowed to dip their *lotas* or buckets into an uninfected well or tank, and should not be allowed even in their vicinity.

(3) Infected wells should be treated with permanganate of potassium. Closed wells are less likely to be infected.

(4) Washing of clothes or utensils nearabout a tank should not be permitted.

(5) Arrangements for drawing water should be made through a man specially appointed for this purpose.

(6) Particular attention should be paid to the cleanliness of the cook and of the cook house.

(7) All privies and drains should be daily disinfected with a solution of cyllin and general cleanliness should be attended to.

(8) Printed circulars for educating the mass to protect against infection should be issued.

(9) All discharges and soiled clothes should better be disinfected by fire.

(10) Water for drinking purposes should be boiled and *not* filtered.

The following **precautions** are **necessary on the first appearance** of cholera :—

(i) Bacteriological examination of the fæces of the patient.

(ii) Bacteriological examination of the water supply.

(iii) Disinfection of the discharges with carbolic or any mineral acid.

(iv) Disinfection of the hands of the contacts.

(v) Disinfection of the infected rooms.

Precautions to be taken on the spot :—

(1) The patient should be removed to a hospital if possible.

(2) All cooked food should be destroyed and cooking utensils disinfected, and all water stored for drinking purposes thrown away.

(3) Persons carrying cholera patients or corpses should be thoroughly washed.

(4) Persons who partook of the same food with the patient should also be placed under treatment.

DIPHTHERIA.

Diphtheria is an infectious disease usually of the mucous membranes transmissible from the sick to the healthy—the cause being a micro-organism (Klebs-Loffler bacillus).

Etiology.—Diphtheria is a widely spread affection and like most infectious diseases is prevalent only in certain seasons. The influence of soil and rainfall upon the prevalence of this disease has led to much discussion and debate. Newsholme holds that epidemics are very common in dry years when the total annual rainfall is materially below average which implies very low ground water. He holds that the micro-organism of diphtheria passes a saprophytic existence in the soil, and that its growth is favoured by a low level of the ground water. The rise of ground water after rainfall drives the micro-organisms out of the soil when it may become parasitic on man and an epidemic arises. This however does not explain the epidemics which commence in dry years unless it be said that the rains falling in dry years are sufficient for the purpose. The diphtheria bacillus has however never been found in the earth.

Epidemics of diphtheria usually commence with the advent of the cold weather, and the maximum death-rate is reached in November and December.

It is believed in some quarters that sore-throat or some damage to the mucous membrane of the throat like catarrh, measles, scarlet fever, &c., predisposes to attacks of diphtheria, but some are peculiarly susceptible to it. The incidence to this disease is mostly limited between the ages of two and twelve years. Age has also a marked influence on the case-mortality.

It is most fatal to infants under one year, it then gradually falls up to the fifth year and after that more rapidly, but rises again after forty.

Mode of Spread.—The most common mode of spread is by personal communication, and outbreaks generally occur in crowded localities, and may be caused either directly or indirectly. Directly the virus may be transmitted through such acts as coughing or kissing, and indirectly by means of handkerchiefs, toys, &c. Cobbett records instances where infection was conveyed among school children through slate pencils. According to Klein milk may be a medium of infection from the cow. It appears that the lower animals may suffer from this disease and transmit it to human beings; among those suspected are pigeons, rabbits, chickens, cattle, dogs and cats.

The *incubation period* is short and varies from a few hours to five days. Patients and nurses may harbour the germs for a long time without showing any outward signs of the disease. These carriers are the sources of infection to others. It is necessary, therefore, that the mouth and throat of such persons should be washed with some antiseptic lotion and the throat sprayed with chlorine water. The mucus from the throat and posterior nares should better be examined bacteriologically, and if there be any suspicion a guinea pig should be inoculated.

One attack gives no protection against a second one. The period of infectiveness has been variously estimated and may be from two to eight weeks. But it is not safe to allow convalescents to mix with healthy children until a fortnight has elapsed after the disappearance of all membranes.

Prevention.—The patient should be isolated and the infected house, furniture, clothes, &c., disinfected. All insanitary conditions should be rectified. Isolation should be continued until the specific bacillus from the secretions of the throat disappears. Milk should always be boiled and any doubtful supply should be stopped at once. All secretions and discharges from the throat should be received in rags and then cremated.

When diphtheria is prevalent, children who have been exposed to the infection should be protected by an injection of the antitoxic serum which possesses prophylactic properties lasting for about four weeks. The ordinary dose of the serum as a prophylactic is 500 units.

SMALL-POX.

Small-pox or variola is a contagious specific fever, attended on the third day of illness by a characteristic eruption of the skin, first papular and ultimately pustular.

Small-pox is known to have been indigenous in Eastern countries and its earliest records are from India and China. Its distribution is world-wide and it is essentially an epidemic disease, although it must be regarded as endemic nearly everywhere in India. According to Holwell small-pox rages epidemically in Bengal every seventh year during the months of March and the two months following it and sometimes until the rains. In India the maximum prevalence of the disease is during the hot weather; while in the cold countries it is most prevalent during the late winter and early spring. The prevalence and mortality of small-pox is much influenced by vaccination. The mortality appears to be higher among males than among females, and the disease is most fatal in children between the ages of two and four. The death rate from small-pox in India varies from 0.3 to 2.0 per 1000 per annum, and about 20 per cent of the persons attacked die.

Infectivity.—The *incubation period* of the disease is usually twelve days, but it may be as short as five days or as long as three weeks. The period of infection lasts for about 6 weeks, but in every case the infected person should be isolated until the last scab has fallen off. The ratio of persons who are entirely insusceptible to small-pox is, according to Notter and Firth, 1 in 20 for adults and 1 in 60 for children. The contagion is very persistent and it may act through a considerable distance. It is exhaled from the skin and lungs of the patient, is probably contained in the secretions and excretions, and adheres to clothing, articles and places with which the patient may have come in contact.

Air is the medium through which the contagion is chiefly transmitted. Houses within a radius of half a mile of a small-pox hospital have been attacked at three times the rate of those between half a mile and a mile, and at four times the rate of those beyond a mile. Whether the disease is spread through the air or through the carelessness of persons connected with hospital is still disputed, and in the absence of any exact knowledge it is better to locate small-pox hospitals as far from inhabited areas as possible.

One attack generally confers immunity for the rest of the life. A second attack, however, is not uncommon and may occur even after an interval of one year. The protection, however, tends to wear off in course of time.

Prevention.—A person may be protected against an attack of small-pox by

(1) an attack of natural small-pox,
(2) inoculated small-pox (variolation), and
(3) vaccination.

1. An attack of small-pox often gives a certain amount of protection, but that following a mild attack is not so lasting. The greater the number of eruptions the more permanent is the protection.

2. *Variolation* consists in inoculating with the virus of small-pox. This either prevents an attack or lessens its severity. This practice prevailed in earlier days and can still be found in some parts of India under the name of "inoculation" or country vaccination.

The chief objections to this method are:—

(i) It causes great disfigurement,

(ii) it diffuses the contagion of the disease and renders the latter most difficult to stamp out,

(iii) there is risk of the inoculated person dying as a result of the operation.

For these reasons laws have been enacted to prevent this practice.

3. Vaccination.

By *vaccination* is meant the introduction into the human system of *vaccinia* which is small-pox attenuated or weakened by its passage through a series of cows. Instead of general eruption all over the body vesicles appear only at the points of inoculation with the result that the small-pox loses its power to spread except in rare cases by aerial convection. Moreover, vaccinia or cow-pox produces only a mild ailment causing discomfort for a few days only.

Dr. Jenner in 1798 first pointed out that the inoculation of man with cow-pox (*vaccinia*) confers immunity to subsequent attacks of small-pox in the same way that an attack of small-pox does to a patient. Many experiments have been made to confirm these results and the practice of vaccination became more general. Cow-pox is small-pox modified or attenuated by the method of " passage " through the bodies of a series of cows and not by a spontaneous disease of the cow.

Duration of Protection.—The protection afforded by vaccination is less perfect and less permanent than an attack of small-pox. The susceptibility to small-pox after a primary vaccination returns slowly, and the duration of protection afforded by vaccination depends upon

(1) the quality of vaccination, *i.e.* the number, area and the character of scars ;

(2) the time which has elapsed since its performance ;

(3) the mode of its performance—vaccination in three or four places gives better protection than that conferred by vaccination in only one spot.

The value of vaccination is evidenced by the following facts :—

(1) Statistics show a gradual decline in the mortality from small-pox amongst the vaccinated. Vaccination was made compulsory in Calcutta in 1880. The mean ratio of deaths per 100,000 of the population per annum for 19 years previous to this was 116·8 and for 19 years subsequent

44·5. In Madras where vaccination was made compulsory in 1884 the result was as follows :

Mean ratio per annum { 1875—84...42 per 100,000.
1885—94... 6 per 100,000.

(2) With the vaccinated mortality is lowest among children under ten, and small-pox is only fatal in later years when the protection from vaccination has faded.

(3) In a population composed of vaccinated and unvaccinated persons the non-vaccinated ones suffer in larger proportion than those vaccinated.

(4) The introduction of vaccination has in all cases been followed by a diminution in the incidence of small-pox.

(5) Compulsory re-vaccination has also suppressed small-pox.

The Operation of Vaccination.—This is usually performed on the outer side of the arm near the insertion of the deltoid muscle. The anterior surface of the forearm two inches below the bend of the elbow or the calves are also selected as sites for vaccination. The part should be thoroughly washed and cleansed, and then the lymph taken on the point of a sterile lancet is inserted by punctures or scratches. The lancet should be held at an angle so as to make valvular incisions which should enter but not penetrate the true skin. It should be sufficient to cause a little blood-stained lymph to exude.

Instructions to Vaccinators.—(1) Vaccinate only healthy subjects. Infants suffering from fever, irritation of the bowels, skin eruptions or chafing or eczema should not be vaccinated.

(2) Do not vaccinate in a house where there is a case of erysipelas.

(3) Never make less than two insertions, four is better.

(4) Particular care should be taken to protect the vesicles ; the crusts should be left until they drop off. Ordinarily no dressing is required.

(5) In primary vaccination only enter as "successful" those cases in which the typical vaccine vesicles have been produced ; in re-vaccination only those in which either vesicles,

either normal or modified, or papules surrounded by areolæ have been produced.

(6) Whenever practicable vaccination should be done direct from the calf or with preserved calf vaccine. In arm to arm vaccination ascertain that the children you take the lymph from are of healthy parentage and have no signs of any hereditary disease, specially syphilis. Lymph should be taken from typical vesicles around which there is no conspicuous commencement of areola.

(7) When performing a number of operations use two lancets, put the used one in boiling water for sterilisation.

A vaccinator should vaccinate at once all the members of a household in case of an outbreak of small-pox in the house, and also re-vaccinate people during epidemics irrespective of the length of time that has elapsed since the last vaccination.

Age of Vaccination.—In Bengal the Vaccination Act enjoins that a child should be vaccinated within six months of its birth, but the best age appears to be four months, that is before the child can turn over. A properly performed vaccination, even to a new born babe, is practically without any danger. Children are very susceptible to small-pox and the younger the child the lesser is the resisting power. If there be any reason to suspect that the child might develop small-pox vaccination should at once be performed.

Re-vaccination is also necessary as the protection afforded by primary vaccination gradually becomes less. Young people should better be re-vaccinated before attaining puberty and during an epidemic. Whenever a case occurs in a house all residents in it should be re-vaccinated. In fact small-pox is entirely prevented if persons are vaccinated two days after exposure, and if on the third day it is "modified" and rendered less severe.

Phenomena of Primary Vaccination.—At the end of the second or third day after vaccination a slight elevation can be felt, and on closer examination about half a dozen small vesicles may be observed which gradually run together and form one large vesicle with a depression in the centre on the fifth or sixth day. The vesicle matures on the eighth day, becomes greyish, tense and loculated, and contains a clear viscid lymph which exudes when the vesicle is pricked. The vesicle begins to be pustular and becomes surrounded by a red ring, the "areola," on the ninth day. During the development of the pock slight constitutional symptoms such as fever, restlessness and itching are observed. About the tenth day it begins to dry up and there remains a dry brown scab about the 14th day, and the scab falls off about the 21st day. The scar or ciccatrix is depressed and marked with little pits (foveated).

Besides vaccination, persons suffering from small-pox should be isolated and the skin smeared with olive or poppy oil or with carbolised glycerine to prevent the contagion from being carried about by air. Infected clothes, bedding, furniture, in fact the whole house should be thoroughly disinfected. All discharges should be received in rags which should afterwards be burnt down.

Antivaccination.—Some persons are opposed to vaccination and they base their arguments as follows:

(1) That vaccination neither prevents nor modifies small-pox.

(2) That it gives rise to other diseases.

(3) That it is unnecessary as small-pox is only slightly infective and can be prevented by isolation.

(4) That compulsory vaccination only interferes with the liberty of the people.

PREPARATION OF CALF VACCINE LYMPH.*

Preparation of Calf.—The calf is kept in quarantine for a week to see that it is healthy. If so, it is strapped to the table and the lower part of the abdomen is carefully shaved. The shaved area is first washed with a 5 per cent solution of carbolic acid and then well-syringed with clean filtered water and finally cleansed with sterilized water. The wetted area is dried by means of sterilized gauze sponges.

---

* Report of the Health Officer of Calcutta for 1910.

Vaccination of Calf.—The calf is then vaccinated with glycerinated calf lymph introduced into the skin by numerous parallel linear incisions by a sterilized scalpel. The scalpel must be frequently dipped in the vaccinating fluid. As these incisions are made, additional lymph is run in along the length by the aid of a sterilized blunt instrument such as an ivory spatula. It is necessary to inoculate the incisions immediately they are made otherwise the lips of the wound are apt to swell and close the opening. After the vaccination, the shaved surface should be covered with a sterilized apron and the calf can then be removed to the stable.

Collection of Vaccine Material.—After 120 hours (five days) the calf is placed on the table and the vaccinated surface is carefully but thoroughly washed with soap and warm water. This may be done either by the clean hands of the operator or with absorbent cotton wool. It is next washed with filtered water and finally with sterilized water. Next any crusts which may have formed should be removed by a sterilized rubber pad. Excess of moisture on the surface may be absorbed by means of sterilized gauze sponges. The skin is then put on the stretch and the vesicles and their contents are collected with a sterilized Volkmann's spoon. Each line must be taken in turn and must only be scraped once. In this way the vesicular pulp is obtained without admixture of blood. The pulp obtained is placed in a sterilized stoppered bottle of known weight. It is then carefully weighed. The abraded surface of the calf is then dusted over with starch or boracic acid powder.

Glycerination of the Vaccine Material.—The lymph pulp is next transferred to a triturating machine—all parts of which should have been previously sterilized by prolonged steaming. The pulp is passed through the machine and thoroughly triturated. To test its complete trituration a loopful of the ground-up material is suspended in a watch-glass of distilled water. If the trituration is complete no particles will be visible and the water will be made merely cloudy.

The pulp is now passed through the machine a second time together with six times its weight of a sterilized mixture of 50 per cent glycerine in distilled water. This mixture of pulp and glycerine water is then once more passed through the machine thus producing a fine and intimate emulsion. Before preparing to store the emulsion, a loopful of it should be taken with a sterilized platinum needle and agar-plates inoculated with it.

Storage of Emulsion.—The emulsion in the machine is received into sterilized glass test tubes of a size that can be filled as completely as possible so that very little air remains in contact with the emulsion. Each tube is plugged with a sterilized cork, is sealed with melted paraffin wax, and is then placed in a dark cool cup-board or ice chest. Each tube should be marked with the number of the calf and the date of the preparation.

The Issue of lymph in Capillary Tubes.—The emulsion may be tested on agar-plates after a month and if no growth is shown the lymph may be drawn into sterilized capillary tubes and used for vaccination purposes. If growth takes place the lymph must be kept for a longer period until it ceases to cause growths. The capillary tubes should be sealed in a flame immediately after they are filled. If the special bottle for filling by means of compressed air be used it must be sterilized before-hand.

General Instructions.—The use of unripe lymph, that is lymph containing contaminating microbes, is followed by fever, inflammation, and perhaps pus production. The use of stale lymyh, generally so after eight months, on the other hand, simply results in more or less failure.

If stored in the cold the lymph retains its activity for a much longer period.

For every operation the Vaccinator must thoroughly cleanse his hands, first with strong soap and warm water, then with a five per cent solution of carbolic acid, and finally with sterilized plain water ; and no assistant must be allowed to touch the vaccinated surface of the calf's stomach before the lymph is taken nor any of the instruments, tubes, sponges, &c., unless with the same precautions.

All glasses, tubes, instruments, gauze, sponges, &c., must be completely sterilized before use and the operator must himself see that the articles to be used are thoroughly sterilized.

CHICKEN-POX OR VARICELLA.

Chicken-pox is a contagious disease occuring in children mostly in an epidemic form. It very often coincides with epidemics of small-pox, but the mortality is practically nil.

Etiology.—There is no doubt that it spreads by a contagium of a previous case of the disease. Personal contact or fomites very often convey the contagium but no specific organism has been isolated. The *incubation period* is about 14 days and the patient should be isolated until the last scab has fallen off.

Chicken-pox and small-pox are separate and distinct diseases and an attack of one does not give protection against the attack of the other. Vaccination gives no protection against chicken-pox. The following scheme presents in contrast the salient features of variola *versus* varicella.*

SMALL-POX.	CHICKEN-POX
Prodromata severe.	*Prodromata slight or absent.*
Heavy sickness, severe pain in back, vomiting.	*Perhaps* slight headache, pain in back, shivering.
Spots come out on 3rd day. Spots come out in progressive order from above downwards—face, hands and arms, trunks, legs, feet.	Spots come out on first day. Spots come out in successive crops, the new spots being widely distributed.
Temperature : three days' pyrexia at onset, and pyrexia again when suppuratian occurs, about the ninth day (called the secondary, or suppurative fever).	Temperature not high as a rule. But pyrexia accompanies each fresh crop of spots if the cruption is profuse.
Liable to have very great complications and sequelæ.	Neither complications nor sequelæ to be reckoned with, as a rule.
The centre of the vesicle is depressed.	The centre of the vesicle is the highest point.
Eruption apt to leave pits, often deep and permanent.	Pitting occasional, and slight as a rule.

---

* Green's Encylopœdia of Medicine.

Prevention.—All cases should be reported to the Health Officer as very often a mild case of small-pox may be mistaken for chicken-pox and thus escape control. It may prevail in an epidemic form, and although not as a rule fatal may give rise to much trouble specially in schools, boarding houses, hospitals, &c. The patient should always be isolated with a special nurse. The measures taken to prevent the spread of small-pox are also applicable to chicken-pox. After separation of all the crusts the patient should have a warm bath and complete change of clothes before regaining perfect freedom. The room should be thoroughly washed and cleaned and all clothes, bedding, &c., used by the patient subjected to a thorough disinfection either by steam or boiling.

MEASLES.

Measles is a specific infectious fever characterised by macular eruptions and wide-spread catarrh affecting chiefly the respiratory, nasal and ocular mucous membranes. It occurs generally in an epidemic form and is infective from its very beginning. Its distribution is universal, and the disease is independent of climatic influences. Children under the age of five are mostly affected, and the mortality is greater among males than females specially among children under two years of age. The death rate is always higher among the very poor and in overcrowded localities.

The *incubation period* is fairly constant and is ten to eleven days in most cases, although it may be as short as six and as long as fifteen days. A true relapse is rare although second attacks are not very uncommon.

Etiology.—Direct contact with a previous case of measles is the most important factor in the spread of the disease. Its propagation may be effected indirectly through the agency of infected articles. The infection may be given off by the breath and mucus. The poison is also diffused through the medium of air and infection probably occurs by inhalation.

Prevention.—The patient should at once be isolated, and infected clothes, bed-room, &c., should be properly disinfected. Application of carbolised oil or glycerine prevents the infection from being carried away by the air.

The following measures exercise considerable control over the spread of the disease :—

(1) Compulsory notification.

(2) Prompt notification to the sanitary authority by the school master of the occurrence of any case amongst the scholars and by the sanitary authority to the school master of any case occurring in the homes of any of the scholars.

(3) In case of any exceptional prevalence the school should be closed.

(4) Removal to hospital of, at any rate, the earlier cases.

TUBERCULOSIS.

Tuberculosis is a chronic infectious disease caused by tubercle bacilli. This includes pulmonary phthisis, scrofula, lupus, meningitis and tabes mesenterica. Men and all domesticated animals may suffer from tuberculosis. Goats are immune to this disease. The disease prevails equally in temperate and tropical climates, although it is comparatively less in colder regions. It is worse in crowded localities and is less in highlands than in lowlands and on the sea coast than in the interior—due perhaps to greater dryness and purity of the air and soil.

In the British army the death rate is ·17 per 1000, in the native army ·52 per 1000, and in the jails 3·21 per 1000. The mortality from tubercular diseases in Calcutta has been as follows :—

1905—2052 : 2·4 per 1000 ; 1·9 for males,
3·3 for females.
1906—2201 : 2·6 per 1000 ; 1·8 for males,
3·7 for females.
1907—2241 : 2·6 per 1000 ; 2·0 for males and
3·7 for females.

In 1908—2101, 2·4 per 1000.
males 2·0 per 1000
females 3·4 per 1000.

For England and Wales from (1901—1905) the
death-rate was 1·9 per 1000.

These figures conclusively show that the disease is on the increase in Bengal, particularly in Calcutta. No race is exempt from the disease, but it is said that coloured races suffer most. Both sexes appear equally liable but the rate of progress of the disease is apparently more rapid in females than in the males. It occurs in all ages but is comparatively less below 5; from 10 to 20 there is a great increase which becomes greater year by year till the later age is reached. This is followed by a still greater increase during the decade from 20 to 30.

Tubercle bacilli have been found at birth in the calf of a tuberculous cow and also in the human fœtus. But the weight of evidence is in favour of the doctrine that direct transmission of tuberculosis from parent to offspring, while possible, is very infrequent.

Etiology.—The bacillus is a minute organism 2μ to 6μ long. It is very thin, motionless and rounded at the ends. It is stained by Ziehl-Neelsen method and shows a beaded appearance—clear spots alternating with the stained parts. The bacilli are usually straight or often slightly incurved. They are aerobic and retain their vitality for a long time outside the body. They thrive at a temperature of 82° to 108° F., and outside the body their existence is only of a parasitic nature. They can live for about six months in a dry state but are readily destroyed by boiling or by sunlight.

Koch maintained that human tuberculosis is different from bovine and that it is not transmissible to cattle. He further holds that bovine tuberculosis is not dangerous to man. This view, however, did not meet with general support and the whole question was referred to the Royal Commission and their report (1907) is as follows :

"There can be no doubt but that in a certain number of cases the tuberculosis occurring in the human subject, specially in children, is the direct result of the introduction into the human body of the bacillus of bovine tuberculosis; and there also can be no doubt that in the majority at least of these cases the bacillus is introduced through cow's milk. Cow's milk containing bovine tubercle bacilli is clearly a cause of tuberculosis and of fatal tuberculosis in man."

Sources of the Bacillus.—In every case the bacilli are introduced from without but the following are the principal sources of infection :

(1) *Expectoration.*—This is the most common source of infection. Dried sputum on handkerchiefs, clothing, bedding, walls, floors, &c., are often carried about by wind in the form of dust, and form the most fertile source of infection. The likelihood of infection is greater in proportion as the persons are dirty or careless in respect of the disposition of discharges. It is greater in dark, lowlying, airless and sunless apartments than elsewhere. It should be observed that apart from discharges the disease is not contagious. "The consumptive himself is not a direct source of danger. It is only his filthy and unsanitary surroundings. Put a consumptive who is careful of his sputum and cleanly in his habits, in a well lighted, and well ventilated room, or, better still, out of doors, and there will be exceedingly little danger of any other member of his family or of those in the house with him contracting the disease. Wherever there is dirt and dust there is danger and there almost alone." (Woods Hutchinson).

(2) *Milk.*—This is another common source of infection. A large number of milch cows are more or less affected with tuberculosis, and it is believed that unless the mammary glands are affected there is no evidence of the milk being infective. The conclusions arrived at by the Royal Commission to enquire into the relations of the human and bovine tuberculosis are : "A very considerable amount of disease and loss of life especially among the young must be attributed to the consumption of cow's milk containing tubercle bacilli. The presence of tubercle bacilli in cow's milk can be detected though with some difficulty if proper means be adopted and such milk ought never to be used as food. There is far less

difficulty in recognising clinically that a cow is distinctly suffering from tuberculosis in which case she may be yielding tuberculous milk. The milk coming from such a cow ought not to form part of human food, and indeed ought not to be used as food at all."

The presence of tuberculosis in cattle is ascertained by the *tuberculin test* which consists in injecting a small quantity of the glycerine extract of pure cultures of tubercle bacilli. If the cow is a tuberculous one, it will produce fever and a marked local inflammation in the neighbourhood of the tubercular foci. It should be observed that human sputum and cow's milk are the principal sources of tubercular infection. Roughly it may be said that *inhalation tuberculosis* is a disease of the young adult life (although it may occur at all ages), while *ingestion tuberculosis* is the disease of child life.

(3) *Meat.*—The flesh itself according to Martin is not infectious but infected glands may be left, or meat during its removal may be infected with tuberculous materials from butcher's hands or knives. The surface of meat however is generally raised to a temperature of over 100°C. during cooking and this source of infection is therefore confined to those cases where glands or imperfectly cooked meat are eaten. The Local Government Board in England have adopted certain recommendations of the Royal Commission on tuberculosis as a guide to meat inspectors in the inspection of tubercular carcases of cattle. (See page 145).

The following conclusion has been drawn by the first Royal Commission on tuberculosis.

"Ordinary processes of cooking applied to meat which has got contaminated on its surface are properly sufficient to destroy the harmful quality. They would not avail to render wholesome any piece of meat that contaminated tuberculous matter in its deeper parts."

(4) The fœces and the urine in cases of tuberculosis of the intestines and the genito-urinary tract respectively and the discharges from tubercular ulcers and abscesses are infective.

Besides the above certain factors predispose a person to tuberculosis; they are chiefly impure air, over crowding, damp soil and insufficient food. Impure air and overcrowding is a constant factor of town-life specially with the poor. Persons living in ill-ventilated damp rooms and on a diet deficient in proteid elements are more susceptible to tuberculosis. This is what usually happens with the poor who usually live in *bustees.* When the houses are built on the vicious system known as " back to back," impurity of air is inevitable which no doubt predisposes the occupants to tuberculosis.

Prevention.—Prevention of tuberculosis depends on the fact that without the tubercle bacillus there could be no tuberculosis. The bacillus must therefore be either destroyed or rendered innocuous. The general characters and life history of the bacillus indicate that sunlight and fresh air are inimical to its growth. As the disease is chiefly propagated by the carriage of the bacillus from an affected to an unaffected individual the secretions and excretions of the former require careful attention. The precautions may more conveniently be considered under the following heads :

A. *Public Measures.*—Considering the increased mortality from pulmonary tuberculosis and the frequency with which the disease attacks persons of working ages and the long duration of illness it is important that every community, large or small, should be made to understand the significance of these measures, which include improved general sanitation. The public should be impressed with the importance of light and air and they should understand that well devised measures for the increase of light and air throughout the town are worth spending money on. There should be ample open spaces, gardens and parks in and near to all congested localities. Factories, lodging houses, offices and places of assembly should be regularly inspected and in all such places provisions should be made for the reception of sputa. Indiscriminate spitting in the streets, public places, conveyances, &c., should be forbidden by law. It is high time that such expectorations should be considered as " nuisance."

It is also desirable that the public should be informed in simple but definite fashion regarding tuberculosis and its prevention. Provisions should be made in all asylums, jails, cantonments, &c., for the separation and suitable treatment of patients suffering from tuberculosis. The possibility of the introduction of the disease through milk and meat should not be lost sight of; and all dairies and slaughter houses should be examined periodically and all suspected animals seized or confiscated.

B. *Private Measures.*—Every one should be impressed with the fact that consumption is not got by exposure to "cold" simply. Light and air increase the resisting power of the cells of the respiratory organs. Bed rooms, sitting rooms, assembly rooms, &c., should be kept open, and more widely the better. Delicate children should undergo suitable lung gymnastics ; these must be directed towards the production of a healthy form of chest and the correction of any existing structural deformity. The more the individual is in the open air the less risk is there of contracting the disease.

The consumptive should not sleep in the same bed with another and if possible not even in the same room. He should not, as a rule, marry. A consumptive should avoid kissing, and a consumptive mother should not suckle. Infection may be prevented from being carried into other parts of the body by insisting on the patient not to swallow the expectoration. Whenever possible a consumptive should change his occupation. If he has a sedentary habit and indoor life he must exchange it for outdoor occupation even at the risk of reduction of his income.

The patient should expectorate in a vessel containing carbolic acid lotion or other disinfectants. The vessel should be changed as often as possible and everytime cleaned and washed with boiling water. The contents should be poured down the water closets or cremated along with soiled rags. Rooms occupied by consumptives should be carefully disinfected. In all suspected cases bacteriological examination of the sputum should be made in order that general prophylactic measures may be taken early.

The following precautionary advice is given to consumptive patients in Brighton :—

PRECAUTIONS FOR CONSUMPTIVE PERSONS.

Consumption is, to a limited extent, an infectious disease. It is spread chiefly by inhaling the expectoration (spit) of patients which has been allowed to become dry and float about the room as dust.

Do not spit except into receptacles, the contents of which are to be destroyed before they become dry. If this simple precaution is taken, there is practically no danger of infection. The breath of consumptive persons is free from infection.

The following detailed rules will be found useful, both to the consumptive and to his friends :—

1.—Expectoration indoors should be received into small paper bags and afterwards burnt.

2.—Expectoration out of doors should be received into a suitable bottle, to be afterwards washed out with boiling water ; or into a small paper handkerchief, which is afterwards burnt.

3.—If ordinary handkerchiefs are ever used for expectoration, they should be put into boiling water before they have time to become dry ; or into a solution of a disinfectant, as directed by the doctor.

4.—Wet cleansing of rooms, particularly of bedrooms occupied by sick persons, should be substituted for " dusting " and sweeping.

5.—Sunlight and fresh air are the greatest enemies of infection. Every patient should sleep with his bedroom window open top and bottom, a screen being arranged, if necessary, to prevent direct draught ; and, if possible, occupy a separate bedroom. The patient need not fear going out of doors in any weather, if warmly clad.

N.B.—The patient himself is the greatest gainer by the above precautions, as his recovery is retarded and frequently prevented by renewed infection derived from his own expectoration.

6.—Persons in good health have little reason to fear the infection of consumption. Over-fatigue, intemperance, bad air, dusty occupations, and dirty rooms favour consumption.

The excellent results obtained from treatment of tuberculous cases in suitable sanatoria is now a settled fact, and it is necessary to secure for the public the advantages of sanatorium treatment. Every civilised country in the world is now provided with them, and an Indian sanatorium would be of immense advantage for the treatment of early tuberculosis. Considering its wide prevalence and that it is an extremely common cause of great suffering and mortality both among Europeans and Indians, it is of urgent necessity that provisions should be made for properly equipped sanatoria in different health resorts in India for the treatment of cases of tuberculosis.

CHAPTER XX.

VITAL STATISTICS.

Vital statistics is the science of numbers applied to the life history of communities. The general state of the public health in every country depends largely on the measure of adjustment of the relation of the individual and the race to the environment, the more complete and continuous the adjustment the greater the longevity. Of the problems of life with which the science of vital statistics is concerned the following are of special importance: population, births, marriages, sickness and deaths.

A thorough enumeration of population as well as registration of births and deaths according to their causes and at different periods of life forms the natural basis of vital statistics. But it is necessary to explain that the vital statistics of India is of a defective character. There is no record of marriages and an inadequate one of sickness. Registration was first introduced in India about forty years ago, but the difficulties encountered have been great. The people doubtful of the object do not like to make their domestic affairs public. The statement of the causes of death leaves much to be desired, as many die without being attended by qualified medical men and attribute all cases of death attended with a rise of temperature to "fever." Further, during an epidemic the real cause of the disease is concealed in order to escape sanitary measures.

In India the first census was taken between 1867 and 1872 and was repeated in 1881 and subsequently at an interval of ten years, and the last was taken in March 1911. The value of these enumerations has been very great, although the return of ages is by no means accurate since the majority of people being illiterate cannot furnish correct ages and occupation. But the figures enable us to make an approximate estimate of true birth and death-rates and of the mortality by age and sex and thus afford data for the construction of a life table.

The following methods of estimating the population have been adopted :

1. If a strict record of emigration and immigration be kept then in a country in which a complete registration of births and deaths is enforced the population can be ascertained by balancing the *natural increase* by excess of births over deaths and increase or decrease due to migration.

2. The increase of inhabited houses in a district being known the increase of population may be estimated on the assumption that the number of persons per house is the same as of the last census.

3. The same rate of increase will hold good as in the preceeding intercensal period, that is that the population increases in a geometrical progression and not in an arithmetical one.

If the census population of a town is 32000 in 1901 and 36000 in 1911, what is the mean population in 1915 ?

If P = population at census of ... 1901

and P^1 = „ „ ... 1911

and if R=rate of increase, then $P^1=P+R^n$ in the nth year. log. P^1=log. P+10 log. R.

$$\tfrac{1}{10}(\log. P^1-\log. P)=\log. R.$$

$$\frac{4{\cdot}556303-4{\cdot}505150}{10}={\cdot}0051153=\log. R.$$

Apply this to the increase in the next 4¼ years.

$$\text{Here } P_{1915}=P_{1911}\,R^{\frac{17}{4}}$$

$$\log. P_{1915}=4{\cdot}556303+\tfrac{17}{4}\,({\cdot}0051153)$$

$$=4{\cdot}578043.$$

By consulting the table of logs. the population corresponding to this number will be found to be 37,848=population at the middle of 1915.

Birth-rate.—An accurate registration of births is as necessary to the sanitary statist as an accurate knowledge of population obtained from census. Births are usually reckoned at a rate per 1000 of population. The *annual* birth-rate of a community is calculated according to the following formula :

$$\frac{\text{number of births in one year} \times 1000}{\text{population}}.$$

The birth and death-rates may be calculated from weekly, monthly or quarterly returns. *Weekly* birth-rates are calculated as follows :

$$\frac{\text{number of births during one week} \times 52{\cdot}17 \times 1000}{\text{population}}.$$

Causes affecting Birth-rates :

1. *Marriage Custom.*—This undoubtedly plays an important part as marriage is a religious obligation with the Indians. Here polygamy is permitted, widowers may remarry, but not the widows as a rule. Marriage usually takes place at an early age and there is a disparity in the ages of husband and wife ; and, as a consequence, an excessive proportion of widows.

Among the Mussalmans, Buddhists, Native Christians and Brahmos the age of females at marriage is generally higher and the disparity in the ages of husband and wife is less ; there is also less restriction on widow remarriage.

2. *Agricultural Distress or Prosperity.*—Birth-rate is a sensitive barometer of prosperity ; with a marked rise or fall in food prices there is a similar movement in the death-rate and an opposite movement in the birth-rate nine months later.

3. *Normal Seasonal Variations.*—Seasonal variations have an influence on the birth-rate. On irrigated tracts with adequate drainage and abundant crops the birth-rate is high ; in waterlogged areas where the soil deteriorates and the people are prostrated by chronic malarial disease there is depopulation from impairment of fecundity.

Still births are not counted either as births or deaths, but are recorded separately.

Death-rate.—Deaths are calculated in proportion to every 1000 of the population, the unit of time being a year. The *annual death-rate* of a place is calculated in the same way as the birth-rate :

$$\frac{\text{the number of deaths in one year}}{\text{population.}} \times 1000.$$

A *monthly death-rate* is estimated as follows :

$$\frac{\text{number of deaths recorded in four weeks}}{\text{population.}} \times 13 \times 1000.$$

Although the registration of deaths in India is defective the recorded rates are generally very high and exhibit a progressive rise.

Transient fluctuations in death-rates may be caused by climatic causes, epidemics or diseases which have a marked seasonal prevalence. Short period rates such as for a week or a month are unreliable except for large populations, but they are useful in exposing certain sanitary changes. The general death-rate of a population is taken as the test of the sanitary condition of a locality.

The sensitiveness of Indian death-rates to sanitary conditions is remarkable, and their fluctuations are greater than those of European populations. This sensitiveness may be attributed to several causes :*

(1) the low age-constitution of the population, which naturally favours a low death-rate ;

(2) the high birth-rate, infantile mortality forming a large proportion of general mortality and being notoriously sensitive to sanitary conditions ;

(3) the early marriage of all girls, which causes the population to breed up to its means of subsistence and renders it easily and extensively affected by want ;

(4) the high death-rate, which is more easily and largely affected by favourable conditions by a low death-rate, and conduces to a low mean age of population. Large fluctuations are commonly due to epidemics of cholera or small-pox, to outburst of malaria and times of scarcity.

---

* McNally and Cornwall : Sanitary Handbook for India.

In order to obtain a perfect idea of the death-rate in a given population or community the total number of deaths in each sex in proportion to the number of the living should be stated. In regard to sex, while the estimated death-rates during 1881-1891 in all ages in India are 40·6 and 38·6 per mille for males and females, respectively, there is a notable contrast in the relative incidence of mortality on the 10—34 age-periods and the rest of life. The female death-rate amongst children under one year is lower than the male, but this gradually diminishes until the age of 6 or 7 is reached. From this age female death-rate begins to increase—the highest being reached at 15 to 20, after which the difference diminishes until at 35 it disappears and thereafter the female rate remains lower. It appears therefore that the highest number of deaths among the females occur during the child-bearing period.

Combined death-rate means the total death-rate of a combination of two or more districts and is estimated from the ratio which the two or more populations bear to one another.

Thus if A has a population of 5,000, B of 10,000 and C of 3,000 with a death-rate of 20, 15 and 25 per 1,000 respectively, then the death-rate of the combined districts with a total population of 18,000 is

$$\left(\frac{5000}{18000} \times 20\right) + \left(\frac{10000}{18000} \times 15\right) + \left(\frac{3000}{18000} \times 25\right)$$

$$= \frac{100+150+25}{18} = \frac{325}{18} = 18{\cdot}05.$$

Now if the average of 20, 15 and 25, *i.e.* 20 had been taken a mistake of 1·95 would have been committed.

Relation between Birth-rate and Death-rate.—It is generally held that a high birth-rate is a direct cause of a high death-rate owing to the great mortality among infants. The death-rate at ages under 5 is three time as high as of all ages together, and a high birth-rate by producing an excessive proportion of persons of tender years will cause a high general death-rate. But the mortality falls if the high birth-rate were to continue longer, for then the proportion of the total population at ages of low mortality would be increased and the general death-rate lowered.

Infant Mortality.—This is calculated on the annual number of deaths of infants under one year to every thousand births registered during the year. Other things being equal it gives an index of the sanitary condition of the place as well as of the density of the population. "Starting from Ireland and progressing East and South there is a gradual and regular rise in the mortality of infants until in India probably one third of those born die within the first year of life, and constitute about 26 per cent of the total mortality."*

The infantile mortality for Calcutta for the year 1911 was 25.16 per 100 births as against 27.35 during the previous year, and for Bengal 18.97 against 19.18 in 1910.

The heavy mortality amongst infants is partly ascribed to immaturity and ignorance of the mother, to improper feeding, to exposure of infants to all insanitary surroundings wherein the causes of malaria, small-pox, measles, bowel complaints and tetanus abound. Illegitimacy, congenital defects and certain hereditary tendencies also contribute materially to infant mortality.

Density of Population.—The density is usually expressed as so many persons to a square mile or an acre. This has an important bearing on the death-rate and exercises a great influence on the population. The greater the density the higher the mortality. Farr states that the death-rate increases with the density of populations, not in direct proportion but in proportion to the sixth roots of the contrasted populations. But this rule does not hold good generally. It is only when the density reaches a certain degree that its bad effects are manifest.

Increased density of population usually means pollution of air, water and soil and a rapid and easy spread of infectious diseases. But in India increased density in country districts may be beneficial to public health by removal of waste lands or cultivated areas. In towns people enjoy certain advantages as regards prompt removal of refuse and supply of a pure and wholesome drinking water, which are usually denied to those who live in villages.

The three most densely populated provinces in British India, according to the census of 1901, are Oudh with 535,

---

* Imperial Gazetteer of India.

Bengal with 438 and the province of Agra with 419 persons to the square mile.

Occupation and Mortality.—Occupation exerts a certain amount of influence on the health and mortality of the people. In order to make correct statistics showing the influeuce of occupation on mortality, the number and the age of those engaged in each calling and the corresponding number of deaths should first be ascertained and the mortality is calculated from the deaths taking place in each particular occupation. This has been very successfully worked out in England and Germany but not in India. Roughly speaking the mortality is comparatively high among workers in cotton, jute or paper mills, or in the manufacture of mineral acids, poisonous metals, &c., or among those whose occupations necessitate constant exposure to sun and rains and to changes of weather. Sedentary occupations have a deteriorating influence on health.

Some occupations require strong and healthy persons and due allowance must therefore be made for the age at which such occupations are followed.

Causes of Death.—It is important to know the rate of death from different causes. It has been stated that "the causes of death in a death register are necessarily little more than the more or less trustworthy guesses of a large body of more or less skilled observers." If this statement applies to England where certificates of death are required either to be signed by a qualified medical man or the coroner one can well imagine how things stand in India where the majority of people die without a proper or rational treatment and where no such certificates are insisted upon.

In India for statistical purposes deaths are classified under the following heads :—

1. Cholera.
2. Small-pox.
3. Plague.
4. Fevers.
5. Dysentery and diarrhœa.
6. Respiratory diseases.
7. Injuries
    - Suicide.
    - Wounds and accidents.
    - Snakes and wild beasts.
8. All other causes.

Zymotic Death-rate.—By this is meant the death-rate from eight principal diseases, *viz.*, small-pox, measles, scarlet fever, typhus, enteric, whooping cough, diphtheria and diarrhœa (including cholera). According to Notter and Firth, rheumatic fever and tubercular diseases should be added to this group.

The *zymotic death-rate* or as it is otherwise known as the death-rate from special febrile diseases gives an index of the general sanitary condition of the place. Of the zymotic diseases measles and whooping cough do not really depend upon insanitary condition, and their excessive prevalence gives no index as to the general healthiness of the community. A high death-rate from enteric fever points to defect in sanitation as well as to pollution of water and soil.

Sickness rate.—The extent of the sickness in the European Army in India may be gathered from the fact that from 1770 to 1856 the men were admitted to hospital at the rate of over 2000 per mille of strength, while the loss by invaliding amounted to 29 per mille. The Royal Commission of 1863 expressed the opinion that a death rate of 20 per mille might 'be taken as the possible mortality under improved sanitary conditions.'

The following comparative table gives the chief causes of sickness and mortality in the European and Indian troops and prisoners, taking the results for five years 1895-9.

European troops.	Cases.	Native troops.	Cases.	Prisoners.	Cases.
Venerial diseases	31·2	Intermittent fever	38.3	Intermittent fever	34·2
Intermittent fever	22·6	Dysentery	5·9	Dysentery	9·9
Simple continued fever	2.4	Venerial diseases	4·6	Abscess, ulcer and boils	9·1
Dysentery	2.3	Respiratory diseases*	3·6	Diarrhœa	6·1
Respiratory diseases*	1·8	Remittent fever	2·1	Respiratory diseases*	3·6
				Simple continued fever	2·3

* Excluding tubercle and pneumonia.

From the above it is clear that the Europeans are specially liable to a class of disorder from which the Indians are comparatively free owing largely to marriage and incarcination.

The registration of sickness for the general population is not feasible although it has been effected in certain companies, societies and institutions like jails, &c. According to Dr. Farr's estimate, two persons are constantly sick for every annual death which occurs, *i.e.* for one death there are two years of severe sickness. The sanitary officer would be in a better position to deal with preventible diseases, if information of the occurrence of every case, whether fatal or not, is supplied to him, and he can only then enquire into the causation of all such cases. It is as important that a correct estimate of the number of persons invalided by sickness should be kept as well as the actual number of deaths.

Probable Duration of Life (*vie probable*) is the age at which any given number of children born alive will be reduced to one half. This can only be ascertained from a life table.

Life Table.—A life table is a true *biometer* because it represents "a generation of individuals passing through time" and measures the probabilities of life and death of this generation at birth, and of survivors at each successive age-period, until the whole generation becomes extinct. The data necessary for its construction are the number, age and sex of the living and the mortality figures of one or more years for the same population classified according to age. Theoretically the ideal plan for forming a life table will be to observe a million life-births, all born on the same day, through life, entering in a column (headed l_x) the number surviving at the end of each succeeding year until all have died; and in a second column (headed d_x) the number dying before the completion of each year of life. This is absolutely impossible to carry out in practice. The only practicable method adopted for making life tables is to assume that the population being given by the census returns and the mortality for each age for a given decennium being known that the same mortality will continue during the rest of the life of the population included in the census returns.

The total mean number living and the total number dying for a given age period are known, the mean chance (p_x) of living one year during this age period is found as follows :—

$$\frac{\text{Population } -\frac{1}{2} \text{ deaths}}{\text{Population } +\frac{1}{2} \text{ deaths}} = p_x$$

It is usual to start with a million or 100,000 children at birth, and to make a separate table for the proportionate number of males and females at birth. Starting with a certain number of babies (l) at birth, if l is multiplied by the probability of living one year the number surviving at the end of the year is obtained. Similarly the number living at the end of the second year is obtained by multiplying the number commencing the year by the probability of their surviving the year and so forth.

From what has been said above it would be seen that if necessary data can be had life tables for individual towns, districts or countries can be prepared. A life table gives a scientific basis on which calculations for life assurance are based.

The *expectation of life* at any age is calculated from the number surviving at that particular age (as obtained from a life table) and from the years of life they subsequently live just as in the mean duration of life (expectation of life at birth). For the ages between 25 and 75 Willich has devised the following formula which gives approximate results :

If x = expectation of life and a = present age, then $x = \frac{2}{3}(80 - a)$.

The *mean duration of life* (*vie moyenne* of the French) can be approximately calculated from Dr. Farr's formula. According to this if b= birth-rate and d= the death-rate per unit of population, then x or expectation of life at birth

$$= \left(\tfrac{2}{3} \times \frac{1}{d}\right) + \left(\tfrac{1}{3} \times \frac{1}{b}\right)$$

Another rough rule for estimating the expectation of life is as follows :—Between the ages 20 and 45 use the fixed number 96. Subtract the present age of the individual from this number and half the remainder is his expectation of life. Between the ages of 20 and 30 the result is slightly below the average, while over 40 it is a bit high. For calculating the estimation of life over 45 take 90 instead of 96 as the fixed number.

The term *expectation of life* means the average number of years which an individual at a given age lives, and so it implies the chances of living of a mixed community and not that any person may reasonably expect to live a given number of years. The mean age of the living is calculated by dividing the sum of the ages of the population at the census by the number of the population. As a test for longevity it is unreliable, being much disturbed by immigration and insanitation.

Colonel Joubert in comparing the expectancy of the lives of the natives of India with those of the Europeans observes that though the constitutions of healthy Indians may not be much inferior to the European standard from a medical point of view, their habits, modes of life and the insanitary conditions amidst which they live are most distinctly inferior to the European standard and render them more liable to acute diseases increasing the risk of assurance. For Europeans and Eurasians living in India the expectation of life as given in the following table has been calculated in some details. Table A is based totally on Indian experience from European and Eurasian lives, while table B on Indian experience from European lives only up to the age of 50.

Age.	Expectation. A	Expectation. B	Age.	Expectation. A	Expectation. B
20	...	33·65	30	25·39	28·26
22	31·43	32·49	32	24·02	27·22
24	29·85	31·41	34	22·72	26·19
26	28·32	30·36	36	21·49	25·16
28	26·84	29·31	38	20·28	24·13

Age.	Expectation.	Expectation.	Age.	Expectation,	Expectation.
	A	B		A	B
40	19·07	23·10	62	7·93	11·39
42	17·86	22·12	64	7·27	10·54
44	16·69	21·18	66	6·62	9·52
46	15·57	20·29	68	5·92	8·54
48	14·53	19·39	70	5·20	7·62
50	13·55	18·43	72	4·50	6·75
52	12·63	17·38	74	3·80	5·95
54	11·71	16·25	76	3·10	5·23
56	10·72	15·09	78	2·41	4·57
58	9·68	13·91	80	1·72	3·98
60	8·72	12·74			

Marriages.—These are usually stated in proportion to the total population, or the number per 1000 of population; but a more accurate method would be to base the marriage-rate for comparative purposes on the number of unmarried persons living at marriageable ages. With the Hindus marriage is an obligatory religious sacrament and is practically universal. The universality of marriage tends to produce a rapid increase of population. About half the total number of males are unmarried and of these three quarters are under 15 years of age. Only one third of the total number of females are unmarried and of these three quarters are under the age of ten and seventenths of the remainder under fifteen.

The great difference between India and England in respect of marriage customs is shown by the fact that in England from three fifths to two thirds of both sexes are single and about a third are married.

There is probably a direct relation between early marriage and the duration of the reproductive functions and the premature strain of the latter tends to their earlier cessation. Dr. Duncan found the average fecundity of women marrying at 15 to 19 years of age was 9·12, and it progressively diminished as ages advanced, being 4·6 for those marrying at 30 to 34 years.

$$\frac{\text{Births}}{\text{Marriages}} = \text{mean fecundity per marriage.}$$

The rapid succession of the generations probably five or more in a century is however favourable to the process of adjustment to an environment that is subject to constant changes.

REFERENCES.

Albutt's System of Medicine
Bombay Medical Congress, Transactions of
Book of Health, The
Bacteriology—Muir and Ritchie
Bacteriology—Hewlett
Cholera—Rogers
Clemesha's Sewage Disposal in the Tropics
Cook's Lectures on Hygiene
Davidson's Diseases of the Warm Climates
Diet in Health and Disease—Burney Yeo
Fevers in the Tropics—Rogers
Food and Principles of Dietetics—Hutchison
Ghosh's Materia Medica and Therapeutics
Green's Pathology
Green's Encyclopedia of Medicine and Surgery
Hygiene and Public Health—Parkes and Kenwood
Hygiene, A Manual of Public Health—Newsholme
Hygiene, Theory and Practice of—Notter and Firth
Hygiene and Public Health—Whitelegge and Newman
Hygiene—Stevenson and Murphey
Indian Insect Life—Lefroy
Imperial Gazetteer of India
King's Manual of Hygiene
Principles of Dietetics—Sutherland
Principles of Hygiene—Simpson
Prevention of Malaria—Sir Ronald Ross
Prevention of Malaria—James
Prophylaxis of Malaria in India—Hehir
Public Health and Preventible Diseases—Lewis and Balfour
Sanitary Handbook for India—McNally and Cornwall
Scientific Memoirs—McCay
Tropical Diseases—Manson
Tropical Hygiene—Lukis and Blackham
Tropical Medicine, Manual of—Castillani and Chalmers
Vital Statistics, Elements of—Newsholme

Review of some of the Recent Advances in Tropical Medicine, Reports of various Sanitary Commissioners and Health Officers, and a number of journals and periodicals.

INDEX.

PAGE.

A.

Absolute humidity 258
Acclimatisation 241
Acids, vegetable 97
Actual dietaries 99
Aerated bread 125
,, water 169
Air 35
,, amount required 48
,, composition of 35
,, cooling of 63
,, diseases due to 42
,, examination of 45
,, heating of 61
,, humidity of 257
,, impurities of 37
,, properties of 37
,, purification 57
Alcohol 173
,, actions of 176
,, uses of 176
Ambulances 289
Amchur 138
Amine process 212
Anemometer 256
Aneroid barometer 254
Animal food 140
,, inspection of 142
,, keeping of 65
,, slaughtering of ... 66
Anthrax 81
Antiplague inoculation ... 331
Antiseptics 295
Antivaccination 344
Ants 271
Arrak 176
Arrowroot 134
Artesian well 6
Atmospheric ozone 260

PAGE.
Atmospheric pressure ... 252
,, electricity ... 260
Atta 123

B.

Bacteria 268
Bael 137
Bake-houses 92
Banana 137
,, flour 137
Barley 129
Barometer 252
,, aneroid 254
,, Fortin's 253
,, reading of... ... 253
Barometric fluctuations ... 254
Baths 229
Bed bugs ... 272, 283
Beef 147
Beer 173
Beetroot 134
Bell trap 201
Berkefeld filter 25
Beverages 168
Birth-rate 358
Biological treatment 213
Blood boiling 66
,, drying 66
Boiling, sterilisation by ... 21
Bone boiling 66
Boots and Shoes 235
Brandy 174
Bran 123
Bran flour 123
Bread 124
,, aerated 124
,, fermented 124
,, unfermented 124
Brick fields 44

PAGE.
Broad irrigation 211
Buffalo-ghee 166
Building site 84
Burgundy 175
Burial 221
Burow pits 80
Bustee 91
,, land 91
Butter 165
,, milk 163

C.

Carbohydrates 97
Carriers 323
Carrots 134
Cauliflour 136
Cellular cloth 234
Cereals 121
Cesspool system 209
Champagne... 176
Chappaties 126
Cheese 164
Chhana 163
Chicken pox 347
Chigger 283
Chimney flues 87
Chocolate 171
Cholera ... 19, 82, 332
,, etiology of 332
,, prevention of 334
,, transport 333
,, virus of 332
Chutney 138
Claret 175
Clay pits 80
Climate 240
,, affected by 240
,, classification of ... 246
Cleanliness 227
Clearing nut 22
Clothing 231
,, for children 235
,, materials for... ... 233
Cloud 264
Cocoa 171
,, action of 171
Cocoanut water 172
Coffee 171
,, action of 171
,, adulteration of... ... 171
,, preparation of 171
Cold bath 229

PAGE.
Combined death-rate 361
Commode system 187
Condensed milk 162
,, ,, skimmed ... 162
Condiments 179
Conservancy 181
Contact bed 216
Continuous filter 216
Contagion 266
Cooking 104
,, of fish 152
,, ,, rice 128
Cooling of houses 63
Corn flour 129
Cotton 234
Country spirit 176
Cowsheds 92
Cow milk 154
Cremation 219
Cucumber 136
Culicides 314
Culifuges 314
Cultivated soil 78
Curd 163
Curdled milk 163
Cysticercus 144

D.

Dahi 163
Daily diet 114
Dals... 130
,, Khesari 131
Dampness of soil 79
Daniell's hygrometer ... 259
Dead, disposal of 218
Death, cause of 363
Death-rate 359
Decomposed eggs 154
Deep wells 6
Density of population... ... 362
Deficiency of food 106
Deodorants 295
Deodorisers 295
Dewpoint 258
Diarrhœa 82
Diet in India 108
Dietaries, actual 99
,, standard 99
Digestibility of food 101
Diphtheria ... 82, 337
,, etiology of 337
,, prevention of ... 338

PAGE.
Diphtheria, spread of... ... 338
Disinfection 295
,, practical methods of 303
Disinfectants 295
,, chemical ... 300
,, natural 296
,, physical 296
Distilled water 13
Distribution of water... ... 15
Domestic filters 24
Drains, testing of 202
Dried fish 149
Drinks, fermented 173
,, non-fermented ... 169
Dumping 182
Dust bins 181
Dysentery ... 19, 83
Duration of life 365

E.

Earth burial 221
Effluvia, effects of 44
Eggs 152
,, absorption of 153
,, composition of 153
,, decomposition of ... 154
,, digestibility of 153
Electricity, atmospheric ... 260
Embalming 218
Endemic 266
Enteric fever ... 81, 322
Enteritis 19
Entozoal diseases 19
Epidemic 266
,, dropsy 128
Examination of air 45
,, ,, water ... 28
Excess of food 105
Exercise 236
,, amount of 238
,, effects of 237
,, rules for 239
Expectation of life 366
Extraction system 52
Extractives... 141

F.

Fans ... 56, 314
Fats ... 96, 141
Fat fish 149
,, melting 67

PAGE.
Feather 234
Fellmongering 68
Fermented bread 124
,, drinks 173
Filter, domestic 24
,, Berkefeld 25
,, four-ghurra 28
,, Pasteur-Chamberland ... 25
Filtration 23
,, intermittent downward 210
Fish 149
,, cooking of 152
,, cultivation of 317
,, inspection of 150
,, tinned 151
Fixed latrines 187
Flap trap 201
Fleas ... 272, 282
Flies 278
,, protection against ... 281
,, tse-tse 280
Floors 88
Flour 123
Food 94
,, absorbability of 102
,, animal 140
,, classification of 94
,, cooking of 104
,, deficiency of 106
,, digestibility of 101
,, diseases connected with ... 105
,, time for taking 103
,, value of 101
,, vegetable 119
Foot rest 185
Fortin's barometer 253
Four-ghurra filter 28
Fumigation 305

G.

Gas stoves 62
Gauge, rain 263
Gases, effects of 43
Germicides 295
Ghee 165
,, adulteration of 167
,, tests for 167
Ghol 163
Gin 175
Gnat 273
Goat 148
,, milk 156

PAGE.
Goitre 18
Grapes 137
Grain whiskey 174
Green vegetables 134
Grit chamber 215
Ground air 73
,, water 74
Gully trap 202
Gut scraping 67

H.

Habit 222
Halwa 127
Hard soap 227
Hardness of water 31
Heat. disinfection by ... 296
Heating of houses 61
Hermite process 213
Hock 175
Hooka 224
Hot springs 5
Houses and buildings ... 84
House, construction of ... 85
,, drainage ... 193, 198
,, flies 279
,, foundation of ... 86
Humidity 257
,, Effects on health ... 244
Hut 91
Hydrocarbons 96
Hydraulic test 202
Hygiene, personal 222
Hygrometer 259
,, Daniell's 259
,, wet and dry bulb ... 259

I.

Ice 4
Ideal latrine 184
,, privy 184
,, well 10
Immunity ... 266, 292
,, acquired 293
,, artificial 294
,, natural 293
,, specific 293
Incineration 182
Incubation 267
Infant mortality 362
Infection 266
,, carriers of 266

PAGE.
Infection, modes of 268
,, restraint of ... 286
Infectious diseases 306
Indian corn 129
Inlets 53
,, common forms of ... 55
Inoculation ... 269, 340
Insects 269
,, characters of 271
Inspection of animals ... 142
,, chamber 199
,, of fish 150
,, of meat 143
Intermittent spring 5
,, downward filtration ... 210
Irrigation on soil 80
,, broad 211
Isobar 255
Isolation 286
,, hospital 289
,, private 288
Isothermal lines 250

K.

Kala azar 321
Keeping of animals 81
Kefir 164
Khesari dal 131
Khitchri 129
Khelat 163
Khir 160
Khus khus 64
Kitchen 281
Koumiss 104

L.

Land springs 5
Larvicides 316
Lathyriasis 131
Latrine 183
,, collecting chamber ... 185
,, floor of 184
,, fixed 187
,, ideal 184
,, moveable 188
,, public 187
,, roof of 184
,, seat of 184
,, trench 186
Lead, manufacture of ... 69
Lean fish 149

PAGE.
Leather 234
,, dressing 68
Lemon 180
Liernur's pneumatic system 208
Linen 234
Lodging houses 90
Long hopper closet 195

M.

Made soil 78
Maggots 279
Maida 123
Main springs 5
Maize 129
Makkai 129
Malaria 306
,, etiology of 307
,, parasite 309
,, prevention of 311
,, quinine in 318
Malignant œdema 83
Malt 129
,, liquor 173
,, whiskey 174
Mango 137
Margarine 165
Marine soap 228
Maximum thermometer ... 251
Mckinnel's ventilator ... 55
Measles 348
Measures, annual 315
,, permanent ... 314
Meat 140
,, characters of ... 143
,, cooking of 146
,, digestibility of ... 147
,, diseases due to ... 144
,, inspection of ... 143
,, preservation of ... 146
Mechanical filter 20
Meteorology 248
Micro-organisms, in soil ... 76
Microscopical examination of air ... 47
,, ,, of water ... 33
Midday sleep 226
Mid-feather trap 201
Midges ... 272, 278
Milk 154
,, adulteration of ... 159
,, composition of ... 154
,, condensed 162

PAGE.
Milk curdled 163
,, digestion of 155
,, digestibility of ... 161
,, diseases due to ... 157
,, effects of heating .. 160
,, epidemics due to ... 158
,, preservation of ... 160
,, tests for 159
Millets 122
Mineral salts 97
,, water 169
Mixed diet 99
Mode of infection 268
Monsoon 256
Morbus bengalensis ... 106
Mortality, infant 362
,, occupation ... 363
Morubba 137
Mosquito 273
,, breeding places ... 276
,, characters of ... 276
,, habits of 275
,, netting 313
,, proof clothes 314
,, protection against ... 313
,, species of 277
Moveable latrines 188
Mustard 179
,, oil 138
Mutton 148

N.

Natural immunity 293
Nesfield's tablets 23
Night-soil carts 189
,, collection of 188
,, depot 189
,, disposal of 189
,, incineration of ... 190
Norton's tube wells ... 6
Notification 286
Nut 136
,, clearing 22

O.

Oats 130
Obstructed drainage ... 79
Occupation and mortality ... 363
Offensive trades 65
Oil 120
,, mustard 138

PAGE.
Oil stoves 63
Open air privy 186
Outfall sewer 207
Outlets 54
Over proof 173
Ozone, atmospheric ... 260

P.

Pan closet 194
Pandemic 266
Papaya 138
Paper making 68
Partition suits 86
Pasteur-Chamberland filter ... 25
Passive immunity 294
Pearl barley 129
Pellagra 129
Pent roofs 89
Perchloride of mercury ... 300
Period of infectivity 267
Permanganate of potash ... 302
Permanent hardness 31
,, latrines 187
Personal cleanliness 230
Phthisis ... 83, 349
Physical examination of water... 30
Pig 148
Plague ... 83, 325
,, bacillus 326
,, conditions favouring ... 328
,, means of spread ... 327
,, prevention of 329
Plantain 137
,, meal 137
Plumbism 19
Pneumatic system 207
Pollard 123
Population, density of ... 362
Port wine 176
Pot Barley 129
Potato 133
,, cooking of 133
,, sweet... 134
Potter's asthma 43
Poudrette 213
Poultry 148
Privy 183
Proof spirit 173
Properties of air 37
Prophylaxis, personal ... 334
,, general 335
Protective inoculation ... 286

PAGE.
Proteids 95
Ptomain poisoning 144
Public latrine 187
Pulses 130
Punkhas 56
Purdah system 85
Purification of air 57
,, ,, sewage ... 213
,, ,, water ... 20

Q.

Quarantine ... 286, 290
,, objections to ... 291
Quinine 318

R.

Radish 134
Rain fall 262
,, gauge 263
,, water 3
,, pipes 89
Rate, death 359
Rat 327
,, flea 282
,, measures against ... 330
Refuse, collection of 181
,, disposal 181
Relative humidity 258
Residential quarters 90
Restraint of infection... ... 286
Retentive soil 79
Revaccination 343
Rheumatism 83
Rice 127
,, cooking 128
,, country 127
,, parboiled 127
,, white 127
Rigor mortis 140
River 12
Roofs 88
Roots and tubers 132
Rum 174

S.

Sago 134
Salted fish 149
Sand filters 23
,, flea 283
,, fly 277

PAGE.
Sand pits 80
Satins 234
Scavenging 181
Scotch barley 129
Scurvy 106
Septic tanks 214
Separate system 203
,, ,, advantages of 203
,, ,, disadvantages of 204
Service privy 184
Sewage 192
,, biological treatment of... 213
,, chemical ,, ... 212
,, disposal of 192
,, farming 211
,, removal of 192
Sewer 203
,, air 41
,, cleansing of 205
,, combined system ... 203
,, disadvantages of ... 206
,, inspection of 205
,, separate system of ... 203
,, ventilation of 206
Shallow wells 6
Shell fish 150
Sherbets 172
Sherringham's valve 55
Sherry 175
Shoes 235
Shone system 207
Short–hopper closet 195
Sickness rates 364
Silk 234
Six's thermometer 251
Slaughtering 66
Slaughter house 66
Sleep 224
Sloping roof 89
Slop water, disposal of ... 191
Small-pox 339
Smoking 224
Smoke test 203
Snow water 4
Soap ... 227,302
,, boiling 67
,, soft 227
,, toilet 227
Socks 235
Soil 71
,, dampness of 79

PAGE.
Soil diseases from 81
,, irrigation of 80
,, micro-organisms in ... 76
,, pipes 198
,, temperature 76
,, varieties of 77
Solar radiation thermometer ... 252
Sooji 123
Sour milk 163
Spirits 174
Sporadic 266
Spraying 304
Springs 4
,, varieties of 5
,, yield of 6
Stables 92
Standard dietaries 99
,, vegetarian diet ... 109
Still births 359
Storage of water 14
Stoves 62
Streams 12
Streaming filter 216
Sub-soil 71
,, water 75
Sullage 192
Sunshine 260
,, recorder 261
Surface soil 71
Sweet potato 134
Synoptic map 255
Syphonic closet 195
Syphon trap 201
,, ,, position of ... 200
,, ,, selection of ... 200

T.

Tallow melting 67
Tanks 11
,, septic 214
Tapioca 134
Tea 169
,, action of 171
,, adulteration 170
,, composition 170
,, preparation 170
,, varieties 170
Temperature ... 242,249
,, effects on health ... 243
,, of soil 76
Temporary hardness ... 31
Terrestrial thermometer ... 252

PAGE.
Testing of drains 202
Tetanus 83
Thermantidotes 64
Thermal springs 5
Thermometer 250
,, maximum 251
,, minimum 251
,, Six's 251
,, solar radiation ... 252
,, terrestrial 252
Ticks ... 272,284
Tinned fish 151
Tobin's tube 55
Toddy 176
Toilet soap 227
Trade, offensive 65
Traps 200
,, position of 201
,, varieties of 201
Trenching ground 189
,, latrines 186
Trichina spiralis 144
Trough closet 196
Tse-Tse fly 280
Tuberculosis 349
,, in animals ... 145
Tube wells 8
Turmeric 180
Typhoid fever ... 19,322

U.

Under proof 173
Unfermented bread 125
Upland surface water ... 4

V.

Vaccine 294
,, lymph 344
Vaccination 341
,, age of 343
,, operation of 342
,, phenomena of ... 343
,, value of 341
Vacuum thermometer ... 252
Valve closet 194
Varicella 347
Varieties of soil 77
Variola 339
Vegetable acids 97
Vegetable butter 120
,, fat 120
,, food 119

PAGE.
Vegetable green 134
,, protied 119
Ventilation 48
,, examination of ... 59
,, external 48
,, internal 48
,, systems of 52
,, vacuum system of ... 52
,, plenum ,, ... 52
Villages, prophylaxis in ... 319
Vinegar 179
Vital statistics 357

W.

Walls 87
Warm bath 229
Washing 305
Wash down closet 195
,, out ,, ... 195
Water 1
,, distribution of 15
,, distilled 13
,, examination of ... 28
,, impurities of ... 16
,, intermittent supply ... 16
,, properties 16
,, purification of 20
,, quantity required ... 2
,, sources 2
,, storage 14
Water-carriage system 181,191,192
Water-closet 193
,, parts of 193
,, varieties of ... 193
Water seal 200
Wells 6
,, area drained by ... 9
,, cleansing of 11
,, examination of 10
,, pollution of 9
,, varieties of 6
,, yield of 10
Well privy 186
Wheat 122
Whey ... 155,163
Whiskey 174
White rice 127
Wind 255
Wines 175
Wool 233

Z.

Zymotic death-rate 364

With HILTON & Co's.
Compliments.

Fourth Edition. **Fourth Edition.**

A TREATISE
ON
MATERIA MEDICA AND THERAPEUTICS
INCLUDING
PHARMACY, DISPENSING, PHARMACOLOGY AND ADMINISTRATION OF DRUGS.

BY
RAKHALDAS GHOSH, L.M.S., CAL. UNIV.,
LECTURER ON MATERIA MEDICA, CALCUTTA MEDICAL SCHOOL.

EDITED BY
LT.-COL. J. T. CALVERT, M.B., M.R.C.P., I.M.S.
PROFESSOR OF MATERIA MEDICA AND THERAPEUTICS, MEDICAL
COLLEGE OF BENGAL, FELLOW OF THE
CALCUTTA UNIVERSITY.

Crown 8vo. *Full Cloth, Page 742.*

Price Rs. 5 or 7*s.* 6*d.*

Opinions of the Press.

The Lancet.—"The major part of the book is occupied by a detailed description of the official remedies including those in the Indian and Colonial Addendum, to the Pharmacopœia, and many unofficial ones. Their nature, source, general characters, official and non-official preparations and doses are given, and then their pharmacology and

therapeutics are discussed. Mr. Ghosh's book is a most useful work of reference, and as the material is well arranged, and the information given is generally reliable, it should prove of value to the practitioner as well to the students.

The China Medical Journal.—"For size, information contained, and the interesting and convenient arrangement of the same, it is the best we have seen. We most cordially recommend it as a book to be used."

The Prescriber.—" The issue of the fourth edition of this excellent book testifies to its continued popularity. The prescribing hints are given at the end of all the more important drugs form a valuable addition. In the two concluding parts of the book a brief but admirable account is given of Serum Therapeutics and Organo-therapy. The part which treats of Pharmacy and Dispensing are exceptionally good, and is full of practical hints which cannot fail to be of the greatest value to the general practitioner. The book deserves our highest praise and can with confidence be recommended to both students and practitioners."

The Indian Medical Gazette.—"The book is undoubtedly one eminently suited for the needs of the local practitioners and officers in charge of isolated dispensaries, whilst the student who has thoroughly read its contents need fear no local examination. We should like to see a copy of this book in the hands of the Medical Officers of local fund dispensaries, whose only literature is too often a copy of the British Pharmacopœia, which is almost out of date by the time it leaves the printers hands."

[illegible]
16 [illegible]